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THE EAST MIDLAND GEOGRAPHER

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CENTRES OF RETAIL DISTRIBUTION IN THE EAST MIDLANDS

P. A. Brown

The Census of Retail Distribution (1950) records the value of retail sales for all the urban districts and boroughs in Great Britain with populations exceeding 2,500.(1) This information is of considerable interest to the geographer since it provides a quantitative index of what is one of the most fundamental and important of urban services. An attempt is made here to describe and interpret the pattern of the value *per capita* of retail sales in the urban settlements of the East Midlands.

Figure 1 shows two patterns, namely, the population pattern of the urban settlements of the East Midlands indicated by the size of the circles, and the pattern of the value *per capita* of their retail sales. The first is shown absolutely, the second by six grades. These grades were selected by plotting the value of *per capita* sales in each of the urban settlements on a dispersion graph, and choosing the scale which best seemed to fit the groupings of values on the graph. Some defects are unavoidable in almost any graded scale but the one chosen here is reasonably realistic since change of grade coincides in every case except the lowest with clearly defined breaks in the dispersion graph.

The General Urban Pattern

Two subdivisions of the general urban pattern of population can be distinguished. The first is the belt of urban concentration extending in the East Midlands from Chesterfield, through Nottingham and Leicester, becoming attenuated towards Kettering and Northampton. It includes all the large cities of the region and a number of medium sized towns, and is characterised also by the large number of satellite towns and urban districts, mainly, though not in every case, grouped around the major centres. The second subdivision comprises the dispersed towns of varied but generally smaller size in the remainder of the area.

The Pattern of Per Capita Retail Sales.

The pattern of *per capita* value of retail sales bears no apparent relationship to size of town and shows four major features.

1. The most widespread feature in the pattern is the larger number of centres with *per capita* sales in the £150-£180 grade. These include : (*a*) the major centres of the urban belt, Chesterfield, Nottingham, Derby, Leicester, Kettering and Northampton but not Mansfield ; and (*b*) a number of centres distributed to the north-east of Nottingham and Leicester, in the area of dispersed towns, extending to Mablethorpe on the Lincolnshire coast.

(1) For details concerning the scope of the Census see *Census of Retail Distribution and Other Services* 1950, *Vol.* 1, *Retail and Service Trades, Area Tables,* H.M.S.O. London, 1953, pp. iii-vi.

2. Second is the striking fact that towns in the £180-£210 category largely occur in one comparatively small part of the region, namely the south-east, and include Market Harborough, Peterborough, Oakham, Stamford, Spalding, Boston and Horncastle.

3. The third notable feature of the pattern is the group of centres in the £120-£150 grade in the northern part of the region, consisting in order from west to east of Worksop, East Retford, Gainsborough, Scunthorpe and Grimsby.

4. Fourthly, the smaller towns of the urban belt, with the single exception of Clay Cross, which is included in the £180-£210 category, invariably have *per capita* sales of value less than £150 and in the majority of cases of less than £120. Cleethorpes, which is in many respects a satellite of Grimsby, also falls into the lowest category, and though located outside the main urban belt it may, with Grimsby, be grouped with the towns of the urban area.

Finally, there remain six towns which are worthy of special note. Two of these, namely Clay Cross and Mansfield, would appear to be anomalous since they are the only towns in the urban belt with *per capita* sales exceeding £180. The remaining four, Brigg, a north Lincolnshire market town, Skegness, a coastal holiday resort, and Ashbourne and Bakewell in the Peak District, are notable for their outstandingly high value (over £210) of *per capita* sales.

Examination of Factors

There appear to be three major factors which affect the pattern of *per capita* retail sales :

(1) The size of the total population served by the shops of each urban centre.

(2) The range and attractiveness of facilities present in each centre.

(3) Variations from place to place in *per capita* purchasing power.

Each of these factors will be examined in turn in an attempt to find how far it conforms with the pattern shown in Figure 1.

The Size of Total Population Served.

Clearly the value of retail sales in any town must bear some relationship to the size of the total population served both in the town itself and in its tributary area or hinterland. It follows that the value of total retail sales per head of the town population alone will vary with the size of the hinterland population. Thus, assuming at this stage a constant standard of living and purchasing power, the *per capita* value of retail sales in a small town with a large hinterland population will be greater than in a large town with a small hinterland population.

The Ordnance Survey Local Accessibility Map of Great Britain(1) indicates the hinterlands served by towns which operate as bus service centres, differentiating between the populations of the towns on the one hand and of their hinterlands on the other. This data, shown in Figure 2, is especially suitable for comparison with Figure 1 since it has been

(1) *Great Britain: Local Accessibility*, 1 : 625,000, Ordnance Survey, Chessington, 1955.
See also : F. H. W. Green, "Urban Hinterlands in England and Wales : an analysis of bus services", *Geog. Journal*, Vol. 116, July-Sept, 1950.

clearly illustrated by F. H. W. Green(1) that the hinterlands defined on the Local Accessibility Map from an analysis of bus services approximate closely to the areas served by the shops of the centres. It is reasonable to expect therefore that there will be some correlation between the proportion of hinterland populations and town populations shown by the Local Accessibility Map and the grading of the various towns in Figure 1.

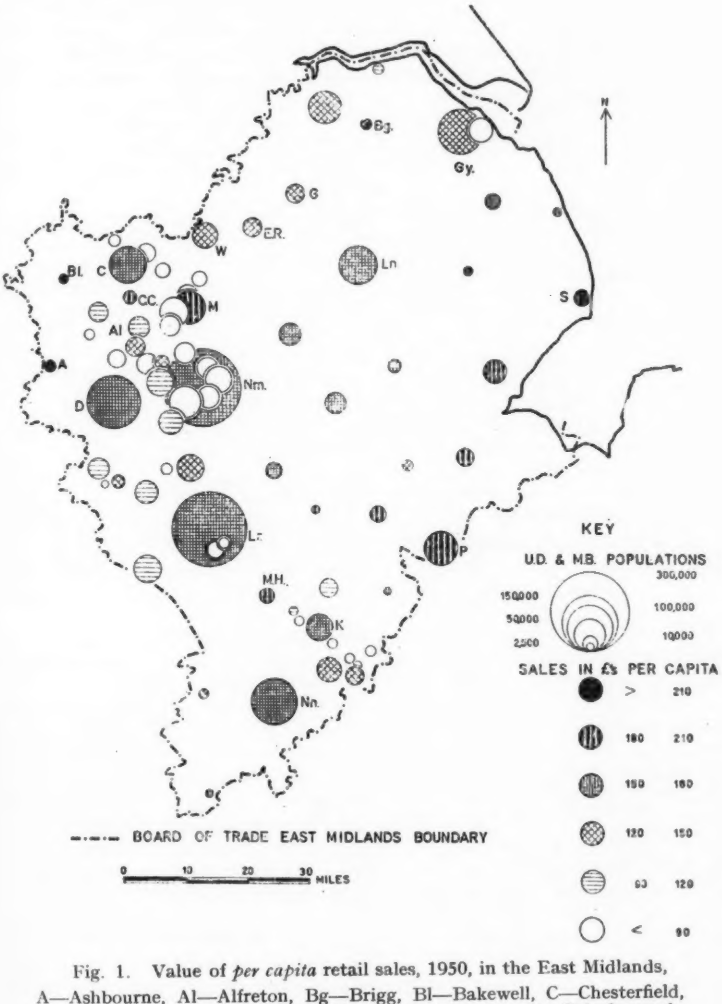

Fig. 1. Value of *per capita* retail sales, 1950, in the East Midlands,

A—Ashbourne, Al—Alfreton, Bg—Brigg, Bl—Bakewell, C—Chesterfield, CC—Clay Cross, D—Derby, ER—East Retford, G—Gainsborough, Gy—Grimsby, K—Kettering, Ln—Lincoln, Lr—Leicester, M—Mansfield, MH—Market Harborough, Nm—Nottingham, Nn—Northampton, P—Peterborough, S—Skegness, W—Worksop.

(1) F. H. W. Green, "Motor-bus services in South-West England, considered in relation to population and shopping facilities", *Transactions and Papers of the Institute of British Geographers*, Publication No. 14, 1948.

In fact this is generally the case in the urban belt of the East Midlands. Chesterfield, Nottingham, Derby, Leicester and Northampton, which are among the towns of the urban area with the highest *per capita* sales, have also large hinterland populations in relation to the population of the centres themselves. Only one other large town in the urban area, namely Mansfield, has *per capita* sales of higher value than these five major centres, but significantly it has a greater proportional population in its hinterland (see Figure 2). In addition, the smaller towns of the urban area, which fall into the lower grades in Figure 1, have correspondingly relatively small and often insignificant hinterland populations, while most of the smaller towns in the lowest category (less than £90) fail entirely to qualify as service centres in Figure 2.

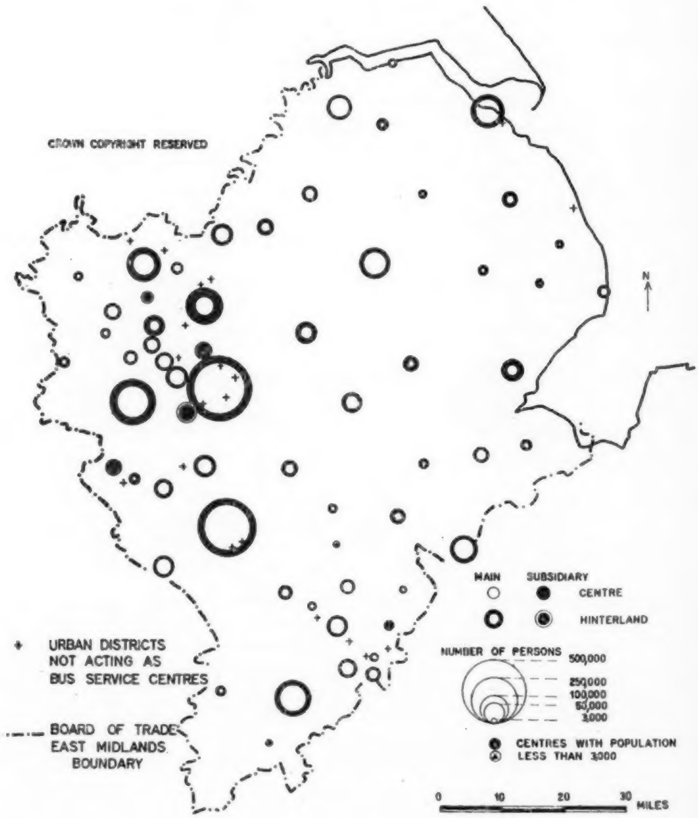

Fig. 2

Bus service centres and their hinterland populations in the East Midlands

It is important to emphasise however that while a correlation is apparent in the urban area it is by no means perfect in detail. Among the more notable exceptions, Clay Cross, though it has *per capita* sales of high value, operates only as a subsidiary bus service centre serving a

small hinterland population. Conversely, Alfreton has a hinterland population which is large in relation to that of the town, yet it has *per capita* sales of low value.

Among the dispersed market towns it is impossible to discern such a general correlation between the two patterns. For example, Brigg alone of the four towns in the highest category in Figure 1 has a hinterland population which is large in comparison with that of the town itself (Figure 2). Spalding has *per capita* sales of considerably greater value than Worksop, yet in both cases the town plus hinterland populations are similar. Oakham is insignificant as a bus service centre and serves a very small hinterland population, yet its *per capita* sales are of high value. Melton Mowbray, Market Harborough and Gainsborough are towns of similar size with similar tributary populations, but each falls into a different grade in Figure 1.

In brief, a comparison of the pattern of *per capita* retail sales with the features indicated on the Local Accessibility Map shows a marked, though by no means perfect correlation in the urban area of the East Midlands, but in the remaining area it is impossible to discern even a broad correlation of the patterns.

The Urban Hierarchy.

It seems important to find not only how far the value *per capita* sales reflects the function of any town as a centre of retail services on a local scale, but also how far it relates to the importance of any town as a centre of more specialised services for a wider area. Smailes has recognised a hierarchy of towns(1) in which the lower grade centres provide services on a basic and local scale, while the higher orders provide services of more specialised and far reaching significance. Since this urban grading, shown in Figure 3, is based upon an appraisal of service facilities it forms a valid comparison with Figure 1.

A comparison of the two maps reveals that there is no close or consistent correlation between the patterns ; in fact the differences tend to be more striking than the similarities. Perhaps the most notable feature to emerge however is the marked disparity between the relative importance in Figures 1 and 3 respectively of the large cities of the urban area. Nottingham, Derby, Leicester and Northampton clearly dominate the urban hierarchy in the East Midlands whereas their grading in Figure 1 is relatively low. Indeed, several of the small dispersed market towns have *per capita* sales of higher value than those of the large cities and many of the former in the same category in Figure 1 (£150-£180) are placed higher on the dispersion graph. This would seem to suggest that as centres for the general run of retail trade the large cities are relatively no more important than the small dispersed towns and while it may be true that they have a greater *per capita* share in certain specialised sections of retail trade within the region the total *per capita* sales of the large cities do not match their rôle as regional centres. Possibly there is evidence here that their importance as service centres for the region at large has in the past been overestimated.

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(1) A. E. Smailes, "The Urban Hierarchy in England and Wales", *Geography*, Vol. 29, June 1944, and "The Urban Mesh of England and Wales", *Transactions and Papers of the Institute of British Geographers*, Publication No. 11, 1946.

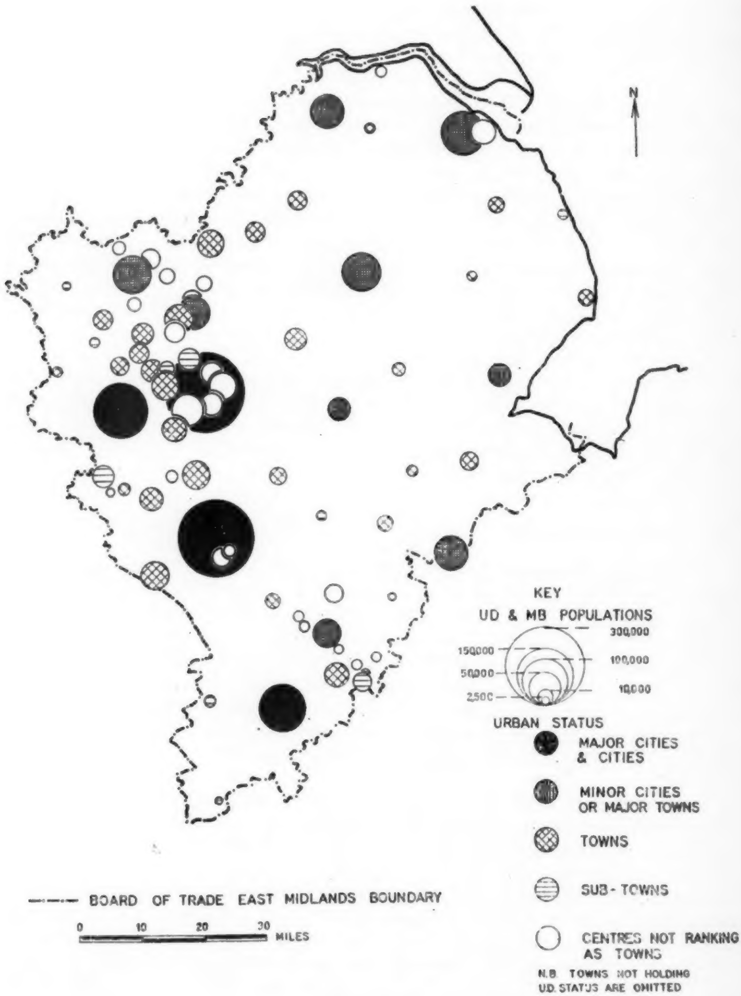

Fig. 3

The urban hierarchy in the East Midlands. After A. E. Smailes, "The Urban Hierarchy in England and Wales", *Geography*, Vol. 29, June 1944

Variations in Per Capita Purchasing Power.

Variations from place to place in *per capita* purchasing power and in standards of living must affect the value of retail trade and *per capita* sales. Unfortunately however, while the importance of this factor is obvious, it is impossible to evaluate its effect over the region as a whole. Nevertheless, it seems feasible and noteworthy that since Holland is

agriculturally one of the richest areas in Britain the high *per capita* sales in the towns of this area in the south eastern part of the East Midlands may be due to high *per capita* income and purchasing power. This suggestion is supported by the evidence that in the areas of Holland remaining outside the urban districts the value of *per capita* sales is higher than in the equivalent area of any other administrative county in the East Midlands(1). The high purchasing power of the seasonal holiday population and of the high proportion of retired inhabitants associated with a coastal resort may account too for the high *per capita* sales at Skegness when combined with its function as a local service centre. It is the combined effect of these factors which is important since the two other holiday resorts, Mablethorpe and Cleethorpes, which do not operate as bus service centres (see Figure 2) have *per capita* sales of much lower value than Skegness.

Conclusion

It is clear from the preceding analysis that the pattern of *per capita* sales does not result simply from the size of the population of the local hinterland served by each centre, nor from the importance of the town within the "urban hierarchy" ; nor is it likely to be the result simply of the spatial variation in purchasing power *per capita*. Undoubtedly each of these factors affects the pattern shown in Figure 1 but too little has yet been done in this field to assess at all fully their relative importance. Thus, the presentation of conclusive findings must await further research into this complicated topic.

THE HIGH SUMMERS OF 1954 AND 1955 AND THE LONG WAVES IN THE WESTERLIES

F. A. Barnes, J. Basten and N. J. Field(2)

The high summer of 1954 was the most inclement since 1922 at Nottingham ; that of 1955 was as unusually genial(3). Both were within the normal range of the British climate, but the persistence of weather of very different types over the chief holiday period in successive years strongly impressed the contrast on the public mind. Seeking reasons for this contrast in the wider context of the general atmospheric circulation, this paper attempts to distinguish in these "abnormal" seasons factors which influence the climate normally in a less striking way. It is hoped to examine the variation of anomalies in the East Midlands in a later study.

After a fairly severe winter and a dry sunny April, every month of the 1954 summer in Britain was wetter than normal. July and August

(1) Value in £s of *per capita* sales in the areas of the East Midland Counties remaining outside the Boroughs and U.Ds. ; Soke of Peterborough 31, Northants 44, Derbys. 50, Notts. 51, Rutland 53, Leicester 55, Kesteven 50, Lindsey 56, Holland 62.

(2) This paper originated as a practical exercise undertaken by J. Basten and N. J. Field in the Spring of 1956 in the course on meteorology and climatology given in the Honours School of Geography, University of Nottingham.

(3) The season of high summer is taken to last from 18 June to 9 September, after H. H. Lamb (see below).

were expecially windy, dull, wet and cool. At Nottingham (Woodthorpe)[1] 80°F was recorded on 12 May, but was not reached again until September. Although May was a little warmer than average, and October the mildest since 1921, the mean monthly temperatures were below normal from June to September: July's was 2·5°F below average (3·5°F in Britain generally) and August's 1·8°F below average (2·3°F generally), both months being the coldest for 32 years. The mean temperature at Nottingham in September was 1·4°F below normal.

The low mean temperatures gave rise to comment particularly because they reflected low day maxima. In July, for example, the mean daily maximum at Woodthorpe was 4·4°F below normal (6°F below at Kew). The temperature reached 70°F on only 6 days (normal 15), and 71°F on only 2 days in the month : it exceeded 70°F for only about 7½ hours compared with a normal 80 hours. The impression of coldness was heightened by windiness, and a sunshine total less than three-quarters of normal.

The 1954 rainfall total of 34·15 inches at Woodthorpe (normal 24 inches) was the highest since 1930, and the 218 rain days the greatest number on record. August was especially wet with 6·08 inches (normal 2·53 inches) and 23 rain days (normal 13). Although the July rainfall at Woodthorpe was well below average there were 17 rain days against a normal 14. The persistence of the summer rains emphasised the bleakness of the season.

Cold, wet, dull and windy conditions still prevailed through the first half of 1955, except for a dry sunny April as in 1954, but from July to December, excepting October, temperatures and sunshine totals were above normal and rainfall below normal. August was especially warm in the Midlands and western England ; yet May at Nottingham was the wettest since 1932 and the coldest since 1941, with appreciable snowfall, while the first 20 days of June were also unseasonably cold and wet. Temperatures rose during the last third of June, and a long warm settled spell began in early July.

At Nottingham 1955 had the warmest July since 1949. The day maximum temperature exceeded 70°F on 22 days compared with the 6 days of 1954, exceeded 71°F on 19 days compared with only 2 in 1954, and topped 80°F on 5 days . Most of Britain had over twice as much sunshine as in July 1954, and many places in the west enjoyed well over 300 hours : Watnall near Nottingham recorded 237 hours. August was even warmer comparatively than July, the mean temperature at Woodthorpe exceeding the average by 4·2°F, surpassed only in 1911 and 1947. It was the driest August since 1947, with rain on only 5 days, and there was fifty per cent. more sunshine than in August 1954. The warm, comparatively dry conditions continued through September into October, although a little rain fell on many days in the first half of September.

Taken together as representative of the high summer season, July and August 1955 in England and Wales had a mean temperature over 5·5°F higher than the same pair of months in 1954, and having only a quarter as much rain they were the driest pair in the whole series of rainfall records since 1869. Indeed July has been drier only four times and August only twice in the last ninety years.

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(1) Data from Woodthorpe are by courtesy of Arnold B. Tinn, Esq.

The Moisture Balance

The effect of the weather of July and August 1955 was still felt in the spring of 1956, when a water shortage was feared, despite the long period of high rainfalls before mid-1955 and heavy rain in early 1956. Potential evapo-transpiration at Woodthorpe (Fig. 1), calculated by Thornthwaite's method[1], normally exceeds rainfall from April through September. The water stored in the soil (about 10 cm.) is expended by mid-July and thereafter soil water is deficient until the end of September.

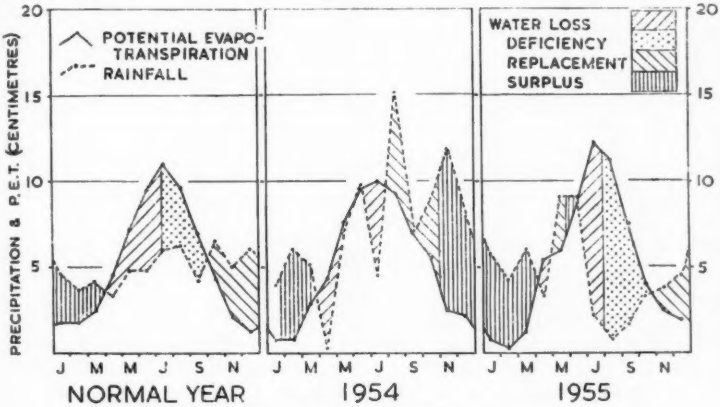

Fig. 1. The moisture balance at Nottingham (Woodthorpe)

The soil water is restored by the end of the year, and from then until early April a water surplus provides run-off. In 1954 with potential evapo-transpiration below normal, and monthly rainfalls high, a condition of water deficiency did not develop at any time. Limited losses of soil water were fully restored by late October, and there was a large untypical water surplus in November and December. The surplus was much greater than normal in the first half of 1955, and despite the high potential evapo-transpiration of April a condition of water surplus was actually restored in late May and June. But from July to September potential evapo-transpiration was well above normal and rainfall substantially below it. All the stored soil water was consumed in July and by the end of August a water deficiency considerably greater than that of the entire normal summer had accumulated. A condition of deficiency lasted until later October, and the soil storage capacity was still far from filled by the end of the year. The rainfall of December 1955 was near normal; that of January 1956 was almost twice normal; and it came as a surprise to many when public water supply difficulties were imminent in some areas in March 1956. But practically all January's large fall in lowland areas was required to restore soil water, and when February's rainfall proved to be less than its potential evapo-transpiration (at Nottingham) it was apparent that the annual period of normal water surplus and run-off was nearing its end without any real replenishment of the reservoirs which had been abnormally depleted during the previous summer.

(1) W. C. Thornthwaite, "An approach toward a rational classification of climate", *Geog. Rev.*, 38, 1948, pp. 55-94. The method is crude for this purpose, but adequate for demonstrating the main point.

According to Thornthwaite's classification Woodthorpe has a $C_2B'_1ra'$ climate. The climatic year 1954 was $B_2B'_1ra'$: 1955, despite the very wet, cold early summer, satisfied the criteria for a $C_2B'_1sb'_3$ climate.

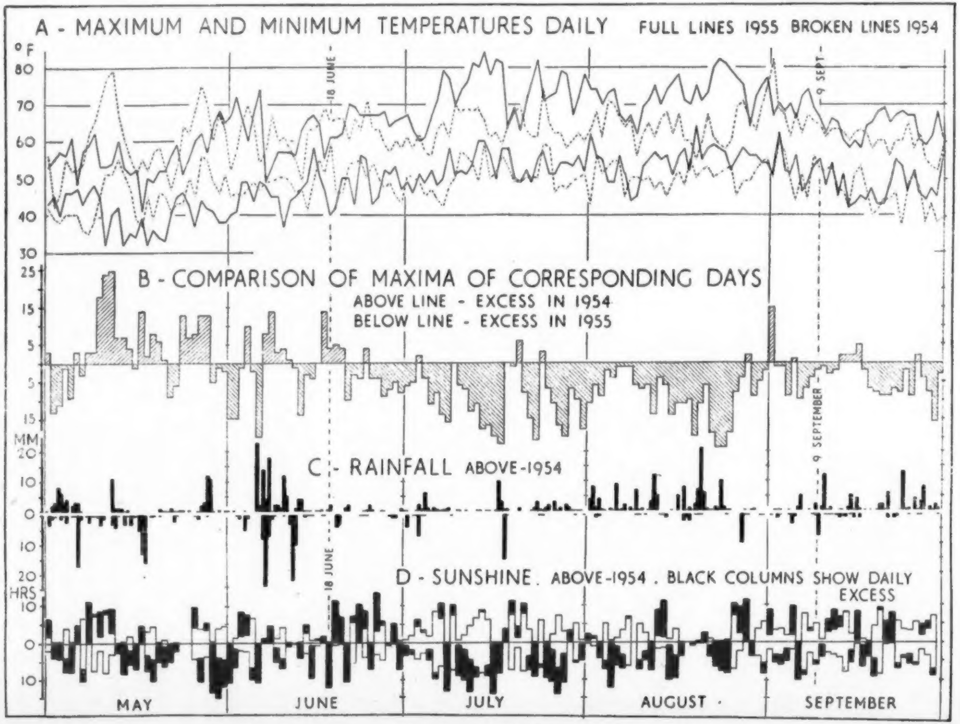

Fig. 2. Summer Weather at Watnall: 1954 and 1955.

The Two High Summer "Natural Seasons"

The comparative day-by-day values of temperature, rainfall and sunshine for the two summers at Watnall, three miles north-west of Woodthorpe, shown in Figure 2, may be regarded as fairly typical of the East Midlands. Graph A shows no marked variation in the general level of the temperature record between late May and mid-September 1954, during which period the maximum temperature reached 70°F on very few days. In 1955 the temperatures in May and June were not notably different from those of 1954 ; in fact Graph B shows that individual May days were more often than not colder than in 1954. Day temperatures in 1955 exceeded those of 1954 increasingly from about 20 June onwards, although the real advent of warm summer weather dates from the first week in July, indicated by a strong rise in the day maxima (Graph A). Thereafter until September the day maximum failed to exceed that of the corresponding day in 1954 only three times, and then by small margins. The graphs of half-daily rainfall (Graph C) and daily sunshine (Graph D) also stress the contrast in the period between early July and late August. Thus the problem set by the weather statistics is to explain why July and August, and to a lesser extent late June, were so different in the two years.

Investigation of recurrent episodes in the seasonal progression, pioneered a century ago by Dr. Buchan, shows that British singularities can often be traced over much of Europe. They must relate to recurring synoptic patterns. Also to be distinguished is the longer "natural season" during which a long spell of some weather type, but not always the same type, is likely to dominate the period in a particular region. Lamb(1) has distinguished five natural seasons in Britain, based on the five distinct groups in the record of the incidence of spells, each marked by a tendency for the synoptic weather patterns established in it to persist or repeat themselves. On average three of the five seasons are dominated by spells each year, and about three out of four English summers are affected by some kind of spell, favourable or otherwise. It is rare to find two long unlike spells sharing one season, and in most cases a single type of spell related to semi-persistent anomalies in the general circulation determines the character of the season. This was the case in the high summers of 1954 and 1955. Over ten per cent. of spells last for 45 days (six and a half weeks) or longer, and the most "abnormal" seasons are likely to be those most completely dominated by one type of spell.

Baur (2) has given statistical proof of a tendency towards a major change in the synoptic situation in Europe in the last third of June—the onset of Lamb's high summer, which lasts in Britain from about 18 June to 9 September. Persistent weather types during the British high summer may be westerly, north-westerly, anticyclonic or hybrid (west or north-west with cyclonic). In 1954 a north-west type dominated the season, while a spell of anticyclonic type dominated in 1955. These two types are likely to give more abnormal averages of the weather elements than westerly or hybrid types. In each case the spell lasted through most of the natural season, so that its abnormality was marked.

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(1) H. H, Lamb, "Types and spells of weather around the year in the British Isles", *Q.J.R. Meteor. Soc.*, 76, 1950, p. 393.

H. H. Lamb, "British weather around the year", *Weather*, 8, 1953, pp. 131-136 and 176-182.

(2) F. Baur,"Extended-range weather forecasting", in *Compendium of Meteorology*, ed. T. F. Malone, Amer.Meteor. Soc., 1951, pp. 814-833.

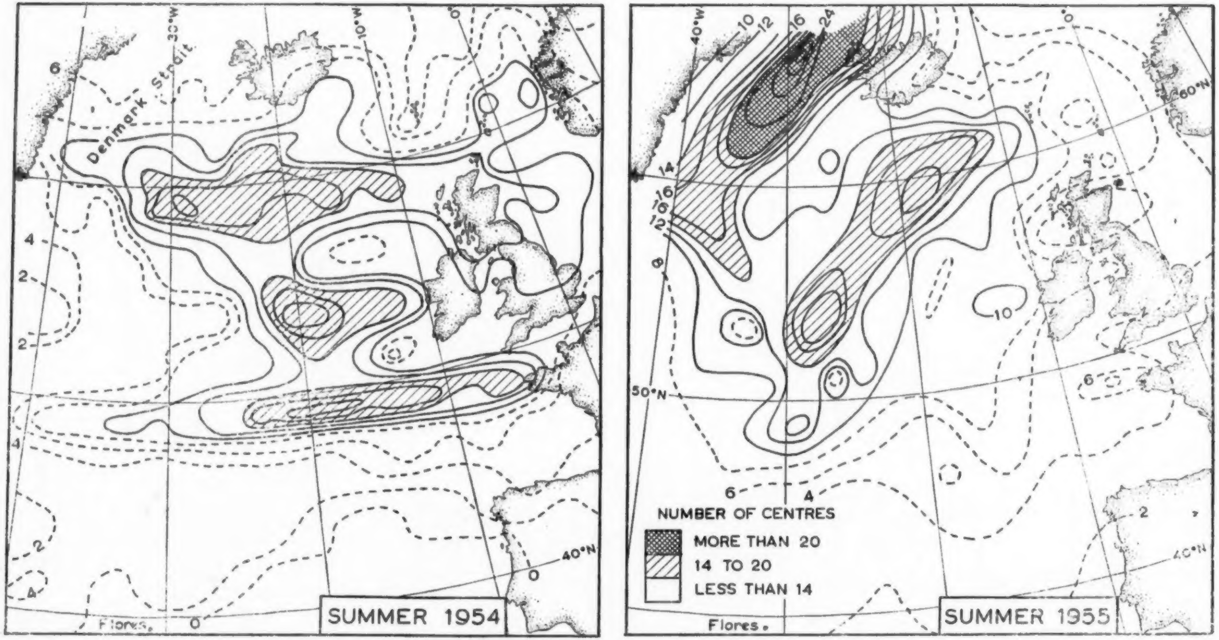

Fig. 3
Depression tracks in the summers of 1954 and 1955
Isopleths are of numbers of depression centres passing through graticule 'squares' between 1 May and 30 September, without regard to depth, area or speed of movement

DEPRESSION TRACKS

The unsettled north-westerly type of weather in the high summer of 1954, with polar maritime air unusually prominent, and the settled anticyclonic character of the 1955 season, suggest that an examination of depression tracks should be helpful. Figure 3 indicates the chief depression lanes from May to September inclusive in the two years. If the maps had been restricted to July and August their dominant patterns would have been even more striking. The depressions of 1954 moved generally west to east or west-north-west to east-south-east in the eastern North Atlantic area; those of 1955 moved mainly from south-west to north-east. In 1954 many depressions crossed, or nearly approached the British Isles. Many of the centres of high summer moved into the southern Scandinavia—northern North Sea area, and becoming quasi-stationary there maintained low temperatures by drawing arctic air southwards over Britain and the North Sea. In 1955 many fewer depression centres approached the British area, moving instead north-eastwards from mid-Atlantic, with a marked concentration of tracks in the Denmark Strait which had enjoyed comparative immunity in 1954. Depressions and their characteristic weather, no less prominent in the north-east Atlantic area in 1955 than in 1954, were distributed in an entirely different way. It is this difference in distribution which is to be explained, with especial emphasis on its consistency over the high summer period. Any consideration of the contrast between the two seasons as an exercise in air-mass climatology must soon run up against this more fundamental problem.

GROSSWETTERLAGEN

De Bort long ago described the "great centres of action", a concept re-stated by Baur, who recognised that cyclones and anticyclones are steered along fairly definite paths by certain large-scale features of the general circulation termed *Grosswetterlagen*. Fluctuations from season to season in the arrangement of these large-scale features causes wide fluctuations in seasonal weather. Until recently there was no technique for their prediction, and it was only in the late 1930's that Rossby(1) and Bjerknes(2) proposed a physical theory of evolution of different forms and positions of the great centres of action.

An examination of many contour and thickness charts(3) for the northern hemisphere brings to light a pattern of major long waves in the westerlies, superimposed on the circumpolar westerly current. Work on the association of anomalies of mean surface temperature and total

(1) C. G. Rossby and others, "Relation between variations in the intensity of the zonal circulation of the atmosphere and the displacements of the semi-permanent centres of action," *Journ. Mar. Res.*, 2, 1939, pp. 38-55.

(2) J. Bjerknes, "The theory of extra-tropical cyclone formation" (in German) *Meteor. Zeit.*, 54, 1937, pp. 462-466.

(3) CONTOUR CHARTS comprise isopleths of height above sea level of a particular pressure surface, say 500 mb. for example. The winds at that level blow along the contours with low heights to the left (in the northern hemisphere) and speed increasing with the gradient. THICKNESS CHARTS comprise isopleths of thickness of the layer between two pressure levels, say 1000-500mb. or 500-300 mb. for example. High thickness represents warmth, low thickness cold. The "thermal wind" in the layer is visualised as blowing along the thickness lines with low thickness on the left, and increasing with gradient. On both types of chart the isopleths are usually drawn at intervals of 200 feet or 60 metres. The relationship of these lines with the surface pattern is seen in Figure 6B.

precipitation over various periods with mean pressure patterns at various levels, including the surface, has suggested that the most promising relationships are with the large-scale contour or thickness patterns of the lower troposphere. In this paper contours of the 500 mb. surface and thickness of the layer 1000 to 500 mb. will be used : on these charts the long waves are very prominent. Their amplitude tends to increase with latitude and decrease with altitude, but their wavelength changes little. They are not independent of surface conditions, for their wavelengths and amplitudes are consistently greater over Asia than over North America, but Namias(1) has shown that they disperse at a speed greater than that of the air movement, emphasizing that the behaviour of any centre of action depends on all others in the same hemisphere. The smallest of these waves has a length of about 4000 miles and a horizontal amplitude of about 550 miles : their length is thus much greater than the order of 1000 miles for waves associated with extra-tropical cyclones. The full pattern in the zone of the westerlies is one of two, or sometimes more, families of waves in different latitude bands, each family containing four to six ridges and troughs distributed round the hemisphere. Wavelengths differ between families, and the wave families are often out of phase. When the waves get into phase major weather changes often ensue.

The Zonal Circulation Index

The pattern of circulation as revealed by upper contour or thickness charts is described in terms of a zonal circulation index which varies cyclically. When the flow of air is essentially zonal the circulation index is said to be high : when the flow is essentially meridional it is low. In the former case disturbances move eastwards in a strong west-to-east flow : in the latter condition the westerlies meander deeply across a zone, and in the most pronounced examples high and low closed circulations form in the upper pattern.

An index cycle—the change from a high to a low zonal circulation index and back—varies from about 3 to 7 or 8 weeks long. Simplified(2) the succession begins with long waves of two families out of phase and extensive zones of confluence between deep polar and deep tropical air, with parts of regional jet streams(3) to the east where these air masses are forced to flow side by side. Coming into phase the waves then combine into deep troughs and ridges which allow a great meridional transport of air. Then the troughs fracture, so that tropical air which has been carried far north is trapped there, and polar air far to the south also has no return path. The upper warm pools in sub-polar regions and cold pools in lower latitudes take on anticyclonic and cyclonic cellular circulation respectively. This is the process of blocking, which commonly leads to a westward propagation of low index circulation patterns which tend to persist. The return of high index conditions, the speeding up of the westerlies, is caused by a re-establishment of the normal north-south thermal gradient due to radiative cooling at higher latitudes and radiative heating at lower latitudes.

(1) J. Namias and P. F. Clapp, "Studies of the motion and development of long waves in the westerlies," *Journ. Meteor.* 1, 1944, pp. 57-77.

(2) For a fuller discussion see H. C. Willett, "Patterns of world weather changes", *Trans. Amer. Geophys. Un.*, 29, 1948, pp. 803-809.

(3) The circumpolar whirl, much obscured at the earth's surface, becomes stronger with height until it reaches a maximum speed in a narrow core of high winds just below the tropopause. This is the jet stream, coinciding with the strongest meridional temperature gradient below it in the mid-troposphere.

It should be emphasized that the total momentum of the mid-troposphere westerlies round the hemisphere tends to have a certain value characteristic of a season, and it is the distribution of this momentum with latitude which varies. Thus a low circulation index in middle latitudes is compensated by strong, high-index westerlies, including the jet stream, further south. However, the total momentum may vary a little in any season from year to year, and its varying distribution in both latitude and longitude also gives rise to regional weather variations.

Blocking Action.

If reasons for seasonal weather anomalies like those under consideration are to be understood, the nature and consequences of blocking action must be appreciated. Blocking occurs when a surface anticyclone developing in comparatively high latitudes in association with an upper thermal ridge (that is, a ridge in the thickness pattern) causes the latter to become distorted. The development term, or "thermal vorticity effect" in Sutcliffe's expression for relative divergence between two pressure levels(1) depends on the rate of change of thermal vorticity, which is made up of curvature and shear. The distortion of the upper ridge by the developing lower pattern is in the direction of sharpening it: its curvature tightens, negative relative divergence increases, and anticyclonic development tends to take place. Therefore the anticyclone, by building, helps itself to build further. Eventually distortion is such that the centre of the surface anticyclone may lie outside the upper ridge pattern, with no thermal steering term and therefore no movement(2). This type of development is most marked when the ridge is confluent. A confluent trough in the thermal pattern also tends to be self-generative, the curvature tightening with development so that cyclogenesis tends to be strengthened—the mechanism of cutting off the cold pool. These two blocking patterns are often complementary and together produce strong blocking action.

The appearance of blocking action in some part of the westerlies obstructs the eastward progress of the waves in the upper westerlies and of the cyclones and anticyclones which are their sea level counterparts. The westerly waves in the mid-troposphere progressively shorten and increase in amplitude as they approach the scene of blocking, with a consequent tendency to form closed anticyclonic and cyclonic circulations in higher and lower latitudes respectively. The fact that the appearance of large-scale blocking in one region is often followed by similar developments in other regions upstream is a further reminder that consideration of seasonal anomalies in any area is a hemisphere-wide problem.

Blocking is thus the beginning of the mechanism which transforms a high index flow pattern into a low index pattern, splits up the major high and low pressure areas at sea level, with major axes north-south rather than east-west, and increases the latitudinal exchange of air masses and therefore air mass contrasts and storminess in the lower middle latitudes. The intensification and expansion of the polar anticyclone is associated with an equatorward displacement of the zonal wind systems and related climatic zones, notably the strong, high index zonal westerlies, including the jet stream, and the prevailing storm tracks.

(1) R. C. Sutcliffe, "A contribution to the problem of development, *Q.J.R. Meteor. Soc.*, 73, 1947, pp. 370-383.

(2) This may be simply interpreted by recalling that surface features tend to move as if embedded in the thickness pattern.

The Climatic Significance of Blocking Action and Low Index Circulation

Since blocking action, once developed, tends to persist, it must have important seasonal effects on weather, which will vary in different regions. As a result of the steering effect wave cyclones guided by the upper pattern are forced to skirt the developing high-latitude anticyclone, either northwards, west of the upper level ridge at high latitudes, or south-eastwards into the cold vortex of lower latitudes. Figure 4A shows actual examples of this effect. The low index circulation developing upstream of the blocking pattern increases air mass contrasts and therefore the vigour of the disturbances, and slowing down their movement west of the block causes anomalously high amounts of cloud and rain, low sunshine totals and a tendency for low average temperatures there due to a combination of low insolation with meridional outbreaks of polar air.

It has been noted that the sequence of any particular month or season commonly takes the form of an alternation between two or more weather types determined by mid-troposphere flow patterns, one of which persistently recurs so as to dominate the mean over longer periods. While the primary index cycle, which usually begins with a strong wave of Atlantic blocking—a necessary though not sufficient condition—varies in both period and detail of development, the variations of the circulation about its normal on mean monthly or mean seasonal charts is far greater than it would be if the circulation types followed each other in random sequence. This is reflected in the wide variability of mean climatic values for a month, a year or series of years, and probably for very much longer periods. Indeed the high index—low index contrast in flow patterns is strongly reminiscent of the differences in circulation which would be expected between interglacial and glacial periods, or other less extreme large-scale fluctuations in climate ([1]). The glacial stages and sub-stages, and other periods of less genial climate like the Stormy Centuries and the Sub-Atlantic probably result from the predominance over various periods of low-index circulations, which would be associated with high index circulations at lower latitudes, and would be repeatedly initiated by blocking action.

The Circulation Patterns of the High Summers of 1954 and 1955

Day to day changes in the circulation patterns of the two summers are closely related to the recorded weather changes (refer to Fig. 2). In early July 1954 cold troughs in the mid-troposphere pattern were moving into Britain from the west. During the second week a broad high index westerly flow over Britain brought some increase in temperature, although minor upper troughs associated with small depressions or troughs at the surface moved eastwards (Fig. 4A) to maintain unsettled weather. This flow was blocked over Russia, and with the development upstream of low index circulation, perturbations of larger amplitude, with deep and vigorous depressions passed into the British area, bringing even more disturbed weather between 13 and 23 July. From 23 July onwards (Fig. 4B) a blocking anticyclone over eastern Canada helped to establish a strong northerly flow on the west side of an upper cold trough over the Atlantic, carrying arctic air from the far

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(1) H. C. Willett, "Long-period fluctuations of the general circulation of the atmosphere", *Journ. Meteor*, 6, 1949, pp. 34-50.

north well southwards, and thereby contributing to the development of very deep depressions which affected the British Isles. Southern Europe shared the wet cold conditions with Britain, but European Russia enjoyed a hot sunny month because it was dominated by the Eurasian blocking anticyclone. June had also been very hot in Russia, Moscow having had its hottest day since 1879 on 27 June, when Austria was suffering exceptionally heavy rain and floods.

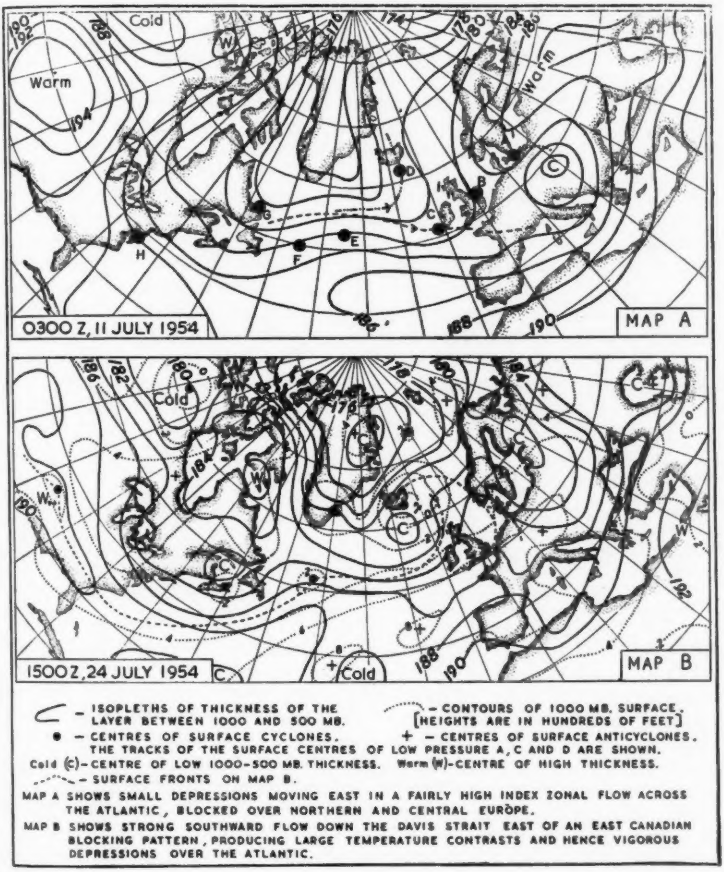

Fig. 4

A—The effect of blocking on depression tracks

B—The relationship of the surface (1000 mb.) and thickness (1000-500 mb.) patterns : an example

About 4 August 1954 the North American blocking pattern retreated to its more usual position in western Canada ; a large upper trough occupied the north Atlantic area with a large complex surface low in the north-east. Rainy weather continued in Britain although the temperature rose a little. By 14 August the upper cold trough had given

way to a normal ridge and trough pattern in the Atlantic area, but unsettled conditions continued, and from 21 to 25 August an anticyclone over the Greenland and Norwegian Seas maintained a north east to north surface stream of arctic air over the British Isles, bringing very low temperatures and dull, showery conditions to the East Midlands. A temporary improvement at the end of the month was due to the arrival of an upper warm ridge, and the extension of a surface ridge from the Azores anticyclone. It did not last long. Again there were heavy rains in southern Europe.

The thermal pattern for high summer 1954 was fluid, but was dominated by low index circulation upstream of a Russian block. In 1955, by contrast, a blocking pattern became established much further west over north-west Europe early in July and persisted for the rest of the month. Temperatures had already shown some rise in fairly high index circulation in later June. The zonal westerlies were backed and confined beyond north-west Scotland, steering Atlantic disturbances far away from the British Isles. While the thermal ridge persisted over the British Isles and Scandinavia, upper cold pools in the thermal trough on its south-east side maintained poorer weather in parts of central Europe, and Yugoslavia had its heaviest summer rainfall for 100 years. During the first week in August the declining ridge of the blocking pattern was slowly displaced westwards by an intensifying upper trough moving south down the North Sea, with a cold front at the surface bringing cooler conditions and a little rain. But between 6 and 9 August an Atlantic upper warm ridge, intensifying, re-established the blocking pattern and cut off an upper cold pool which moved to central Europe, and later brought thundery conditions to southern Britain between 10 and 15 August. A little rain at Nottingham in the next few days was associated with an intense upper cold trough approaching from mid-Atlantic with increased cyclonic activity, but the upper ridge and anticyclonic conditions were again re-established during the following week. At the end of the month cooler and less settled conditions were caused by another deepening upper trough on the Atlantic.

The thermal pattern of July-August 1955 in the British area was more stable than that of 1954. The different position and form of the blocking pattern which controlled the summer weather completely altered the orientation of depression tracks and their location relative to the British Isles. The changed orientation was due essentially to the opportunity for the high-latitude anticyclone to link up with the Azores high pressure cell, greatly extending the area of blocking to the south-west. This is well seen in Figure 5, which shows how the position and shape of the general areas of persistent blocking would affect the steering of surface pressure patterns in July.

The Mean Mid-Troposphere Pattern and its Significance

While the influence upon weather of short period variations in the *Grosswetterlagen* is readily demonstrated, Namias and Clapp[1] have found that monthly mean circulation patterns without doubt determine monthly weather anomalies. They have shown also that physical reasoning can be applied to the mean maps, an important conclusion for the climatologist. Figure 6 shows the upper patterns of the North Atlantic area for July 1954 and 1955, which are representative also of

(1) J. Namias and P. F. Clapp, "Studies of the motion and development of long waves in the westerlies", *Journ. Meteor.* 1, 1944, pp. 57-77.

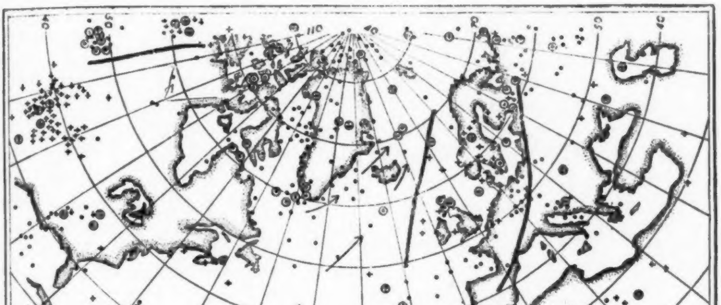

Fig. 5

General location of blocking patterns and expected depression tracks in July 1954 and 1955

Centres at 0300 and 1500 G.M.T. daily.

August. The average 500 mb. contour chart for July 1954 reveals a pattern, less definite than that of 1955 because of the greater fluidity, which includes an upper cold trough east and north-east of the British Isles, extending its axis north-westwards. In the North Sea area this trough was markedly diffluent. Consideration of the shear and curvature effects in the development term of Sutcliffe's expression for relative divergence[1] shows that there was a tendency to anticyclogenesis (or cyclolysis) behind the axis of the trough in the Azores-Iberia area.

(1) R. C. Sutcliffe, 1947, op cit. Note that Sutcliffe's expression relates to the thickness pattern, but this is generally similar in form to the contour pattern shown.

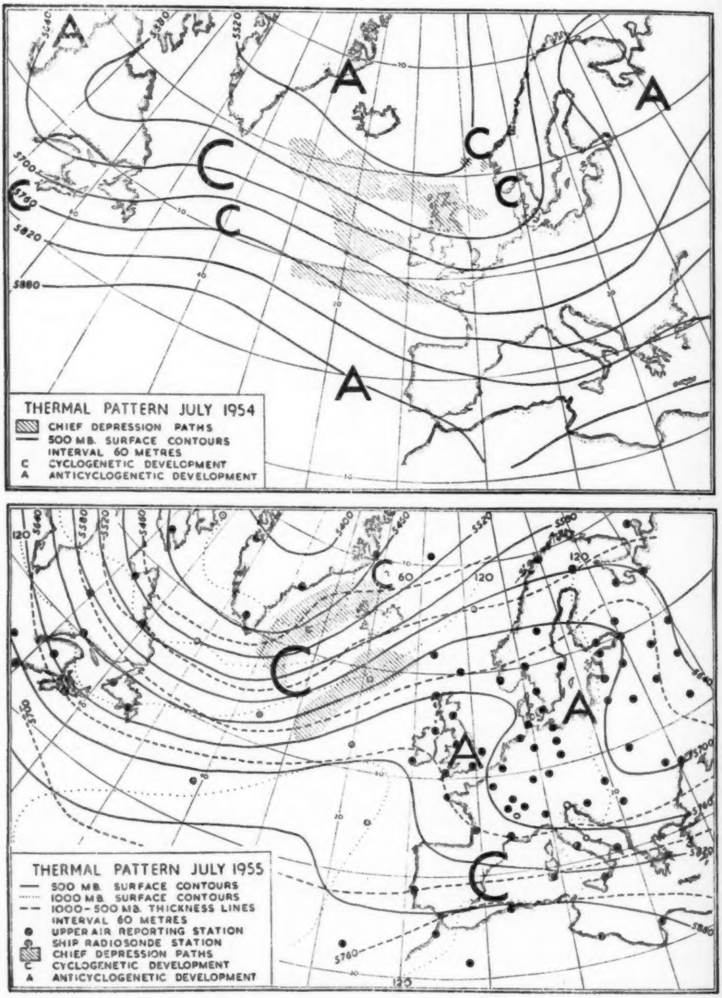

Fig. 6

Mean thermal patterns in July 1954 and 1955, with an indication of the localities in which development would be expected.

The map for July 1955 shows the general similarity between the 1000-500 mb. thickness and the 500 mb. contour patterns, and the relationship of these to the 1000 mb. contour pattern, which is virtually the same as the surface pressure pattern.

Cyclogenetic development near to and ahead of the axis to the north, in the north-east North Sea or southern Scandinavia, would tend to induce depressions approaching by steering to move by development into that area. This took place in July 1954 and may be discerned on the whole-summer map of depression tracks. The slightly diffluent ridge over northern Scandinavia would be expected to encourage anticyclogenesis in western Russia, where a blocking anticyclone did exist for much of the month. The confluent trough over south-east Canada, combined with a ridge to the north-west to produce a blocking pattern, with cyclogenesis in the Nova Scotia area. Cyclogenesis would also be expected in mid-Atlantic, especially about 50 to 55°N, 40°W in the weak ridge pattern in the zonal westerlies, while anticyclogenesis is indicated in eastern Greenland. It is in accord with expectation that in July 1954 disturbances formed or intensified in mid-Atlantic and near southern Greenland, east of the North American block, and moved east or east-south-east by steering until blocked in the North Sea area, to maintain cold air streams over Britain. Both steering and development terms indicate the protection of the Denmark Strait from penetration by depressions.

In the western European blocking pattern of July 1955 anticyclogenesis is indicated over the British Isles or western Baltic, with a tendency for cold pools to be cut off over central Europe. Cyclogenesis would be expected between 50 and 65°N and 30 and 40°W immediately east of the axis of the wide trough from southern Greenland, and also in the area between Greenland and northern Scandinavia, so that depressions formed in the former area would be guided into the latter by both steering and development effects.

Factors External to the Atmosphere

The fundamental reasons for the contrast in the weather of the two high summers are those which can explain the occurrence of predominantly low index circulation and the location of the blocking action. Baur(1) proves that *Grosswetter* do not evolve by chance plus a "persistence tendency". High and low index circulation patterns are world-wide in character and appear to express the operation of some mechanism of basic significance to all fluctuations of circulation. A similar oscillation between these two definite types of pattern is probably found through the whole spectrum of weather variations, from weekly anomalies to ice ages, pointing to some universal disturbing impulse which varies irregularly in cycles of varying length since the amplitude of the fluctuations does not decrease with the period. No mechanism yet suggested other than solar variability can explain all the irregular weather variations in periods of very varying length, and even this relationship is still far from proven.

The only ready index of solar variability is provided by sunspots, but since the variability appears to be mainly in the far ultra-violet part of the solar spectrum its relationship with the sunspot number is at best approximate, and its effects likely to be greater on the stratosphere than on the lower troposphere. Yet during the stormy thirteenth-fourteenth centuries sunspots were large and numerous while from 1672 to 1704, an unusually tranquil period, not a single sunspot was recorded.

(1) F. Baur, "Extended-range weather forecasting", in *Compendium of Meteorology*, ed. T. F. Malone, Amer. Meteor. Soc., 1951, pp. 814-833.

The suggestion of correlation between increased solar energy emission and climatic stress has much support. Simpson([1]), for example, believes that an ice age requires an increased solar constant, which would lead to an increased latitudinal temperature gradient and an increase in low index circulation. Cooling would be mainly confined to zones of convergence and storm tracks, and though a continued increase in solar emission would lead to a rapid general breakdown to warm, very wet conditions, this apparent difficulty in fact could explain warm interglacials both wet and dry and the extremely heavy Pleistocene rainfalls required by Dury to explain misfit streams in meandering valleys([2]). Starr([3]) considers that relatively high pressure in high latitudes, that is, blocking, is a necessary condition for, but does not require, the poleward transport of heat and kinetic energy, and Simpson's theory fits Starr's hypothesis. If the solar fluctuations were mainly in the ultraviolet wavelengths, largely absorbed in the ionosphere, they might not affect the temperature of the troposphere sufficiently to interfere with glaciation over long periods.

Much evidence suggests also the influence of solar variability on shorter period fluctuations. For example Helland-Hansen([4]) has shown that prevailing storm tracks across the North Atlantic tend to be displaced equator-wards in high sunspot periods. In fact the sudden outbursts of shortwave radiation and charged particles accompanying eruptive activity of the sun can considerably heat the higher atmosphere in a few hours, leading to a rise of sea level pressure polewards from the latitude of maximum heating([5]). The fact that large temperature changes may be caused by small changes in radiative flux in the low-density high atmosphere has led Palmer([6]), Farthing([7]) and others to suggest a connection between radiative effects at high levels, notably in the ionosphere, and surface synoptic features, although the physical mechanisms remain obscure.

If variations of insolation produce important effects it might be supposed that fluctuations in the opacity of the upper atmosphere would be significant, although this has been denied([8]). Defant([9]) has

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(1) G. C. Simpson, "World climate during the Quaternary period", *Q.J.R. Meteor. Soc.* 60, 1934, pp. 425-478. An increase in latitudinal thermal gradient causes an increase in the speed of the zonal westerlies to some critical value at which a change to low index circulation is required to reduce the thermal gradient. Increased solar emission leading to increased thermal gradient would therefore be expected to increase the tendency to low index circulation. The theory of a decreased solar constant to explain glaciation put forward by R. F. Flint (*Glacial geology and the Pleistocene epoch*, 1947) cannot be sustained.

(2) G. H. Dury, "An approach to palaeometeorology", *Nature*, 172, 1953, p. 919, and "The shrinkage of the Warwickshire Itchen", *Proc. Coventry and Dist. Nat. Hist. and Sci. Soc.*, 2, No. 7, 1953, pp. 208-214.

(3) V. P. Starr, "A physical characterisation of the general circulation", *Dept. of Meteor., Mass. Inst. of Tech.*, 1949.

(4) B. Helland-Hansen and F. Nansen, "Temperature variations in the North Atlantic ocean and in the atmosphere," *Smithson. Misc. Coll.*, 70, 1920, No. 4.

(5) B. Haurwitz, "Relation between solar activity and the lower atmosphere", *Trans. Amer. Geophys. Un.*, 27, 1946, pp. 161-163.

(6) C. E. Palmer, "The impulsive generation of certain changes in the tropospheric circulation", *Journ. Meteor.*, 10, 1953, p. 1.

(7) E. D. Farthing, "A possible relationship between the solar corona and weather conditions in the central Mid-West", *Bull. Amer. Meteor. Soc.*, 36, 1955, p. 427.

(8) See discussion in report of paper by G. J. Day, *Met. Mag.*, 85, 1956, p. 112.

(9) A. Defant, "Die Schwankungen der atmospharischen Zirkulation uber dem Nordatlantischen Ozean im 25-jahrigen Zeitraum 1881-1905", *Geog. Ann.*, Stockh., 6, 1924, pp. 13-41.

suggested that violent volcanic eruptions which markedly reduce insolation disturb the North Atlantic atmosphere to an oscillation with a period of about 3½ years, rapidly damped. A decreased meridional pressure gradient, that is, presumably, low index circulation, is favoured for about two years, followed by a higher index. Opacity of the upper atmosphere was abnormally high between October 1953 and March 1954 after an eruption in Alaska in the summer of 1953, and it could be argued that this was followed by two years of markedly low index circulation, substantiating Defant's findings. In fact, however, a reduction of insolation would be expected to favour high index circulation first.

It must be concluded that solar variability is the most probable mechanism controlling the circulation index in short as well as long periods. No information on this factor has been obtained, but it would be expected that the period 1954-1955 was one of higher than normal solar constant.

While solar variability may be the basic cause of glaciations and shorter aberrations of climate, the distribution of insolational heating and orography probably determine their patterns, and perhaps are necessary though not sufficient conditions(1). Lamb(2) notes significantly that the beginning of early winter in Britain about 20 November coincides with the normal completion of snow cover in eastern Siberia, and the first fixing of a great cold trough in the upper westerlies near the east coast of Asia, a major event which affects the spacing and movement of other weather systems all round the hemisphere. This implies that the great change in the albedo and the thermal properties of the eastern Siberian land surface leads to the development of a blocking pattern there as the surface anticyclone produced by cooling interacts with a warm ridge aloft. Other large-scale changes and contrasts in the albedo or thermal properties of the surface—perhaps even the development of crops over large areas—may initiate far-reaching developments of this kind at different times of year. Further, according to Bolin(3) and Wexler(4) the mountains of interior Asia may be important in generating planetary waves, and contributing thereby to the fixing of blocking patterns. Any attempt to isolate the operation of the factor of insolation in the present instances would entail a large-scale research project which cannot now be entered upon.

Summary and Conclusion

The fine high summer of 1955 in the British Isles in general, and the East Midlands in particular, was associated with a blocking anticyclone developed and sustained over the area through July, and less continuously through August. By contrast the inclement summer of 1954 was dominated by a mainly north-westerly weather type related

(1) G. C. Simpson, "Possible causes of change of climate and their limitations", *Proc. Linn. Soc.*, 152, 1940, pp. 190-219.

(2) H. H. Lamb, 1953, op. cit.

(3) B. Bolin, "On the influence of the earth's orography on the general character of the westerlies", *Tellus*, 3, 1950, p. 192.

(4) H. Wexler, "Some aspects of dynamic anticyclogenesis", *Univ. of Chicago, Publications in Meteorology*, 8, 1943, p. 26.

to a more fluid low index circulation pattern upstream of a blocking pattern in the westerlies over eastern Europe. This Russian block, together with another over eastern North America produced a pattern in which, for example in later July, a deep upper trough east of Greenland brought arctic air down the Davis Strait and gave rise to unusually deep Atlantic depressions which affected the British Isles. Fundamentally the contrasting weather in the two years was due to the fact that both seasons were characterised by low index circulation, which might be explained by an increased solar constant, but the position of the blocking pattern which initiated it varied, perhaps due to differences in the broad pattern of insolational heating over the hemisphere. Neither of these mechanisms can be specifically related to the weather in the period under examination. However, measurements of solar radiation from rockets or artificial satellites should before long clarify the relationship between solar variability and short-period weather anomalies. If the relationship is positive there is every reason to hope that problems of greater moment than the varying weather of the holiday period may be solved thereby, and a unified concept of physical climatology may be founded upon it.

EAST MIDLANDS COAL PRODUCTION IN RELATION TO BRITAIN'S FUEL AND POWER PROBLEM

K. C. Edwards

Coal is by far the greatest of Britain's natural resources and was the chief means by which her industrial supremacy of the nineteenth century was achieved. Further, the large quantities of coal exported abroad helped greatly in the development of Britain's highly specialised forms of manufacturing. Both coal production and export tonnage reached their peak just before the first world war. In 1913, output reached 287 million tons, of which 98 million tons (about one-third) were exported. Afterwards, for various reasons outside the scope of this article, both production and exports steadily diminished. This decline became acute during the second world war and its immediate aftermath, until it was arrested in 1947. Since then output has been maintained at about 220 million tons a year, but Britain has now almost ceased to be a large-scale coal-exporting country. In the meantime the home demands for coal have steadily risen.

These changes have affected the individual coalfields differentially (see Figure 1). In general, before 1913, the most fully exploited fields were those located nearest the seaboard, i.e. those which could most readily participate in the export trade. Thus by 1913 the South Wales Lancashire, Cumberland, and Northumberland and Durham fields together with those around the Clyde in Scotland, had reached or passed their peak of production and have since, to varying degrees, declined. Since 1913 the importance of inland fields (Yorkshire, Derbyshire and Nottinghamshire, and some others in the Midlands) has steadily grown. The Yorks., Derbys. and Notts. field, besides having the greatest proved reserves, is now the most productive in the country, raising over 40% of the national output (actually 43% in 1955).

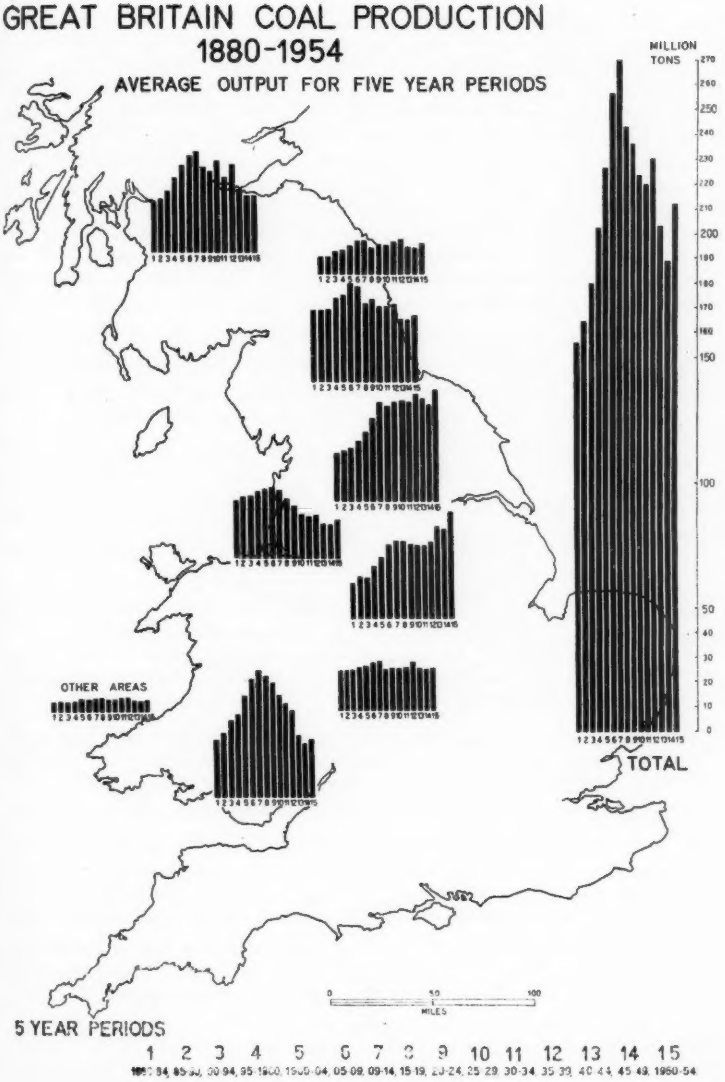

Fig. 1
(Data from Colliery Yearbook and Coal Trades Directory, 1955)

THE N.C.B. EAST MIDLANDS DIVISION

Since the nationalisation of the coal industry in 1946, this field has been divided for administrative and operational purposes to form two separate Divisions of the National Coal Board, the northern (or Yorkshire) portion forming the North Eastern Division and the southern (or Nottinghamshire and Derbyshire) portion the East Midlands Division.

The latter also includes the small but highly productive South Derbyshire and Leicestershire field. Judged in terms of National Coal Board Divisions, the East Midland area is now the most important of all as regards output, raising 46 million tons in 1955, 38 million tons from the main field and 8 million tons from the smaller one(1). It is the only area to record an increase in production for every year without exception from the period of depression in the early 'thirties, including the second war during which the national output dropped sharply. While there are obvious objections to the separate treatment of what is part of a single geographical entity, the Yorks., Derbys. and Notts. coalfield, there is, as will be shown, some justification for this procedure, quite apart from the fact that National Coal Board statistics are now drawn up on a Divisional basis.

The general features of the main field within the East Midlands Division are well known but the following facts should be noted :—

(1) The field, which is 35 to 40 miles long from north to south, has a breadth from west to east varying from 12 to 20 miles.

(2) It may be divided into an "exposed" portion to the west in which the Coal Measures appear at the surface and a "concealed" portion to the east in which the Coal Measures continue eastwards beneath the Permo-Trias cover (see Figure 2). The "exposed" portion was naturally worked earlier and consequently contains the oldest mines.

(3) Only part of the "concealed" portion has so far been exploited, while the actual reserves and the eventual limit of working have yet to be precisely determined. Recent borings indicate considerable reserves at workable depth both east and south of the Trent beyond Nottingham.

(4) The seams are relatively undisturbed and extend for considerable distances without serious deterioration in quality or marked change in thickness. (Taking the field as a whole however, certain of the more valuable seams exhibit some deterioration eastwards.)

(5) While many seams are worked, none are very thick. They mainly provide good steam (or industrial) coal and high grade domestic coal. Good class coking and gas coals are restricted to a few seams in the northern part, chiefly between Mansfield and Chesterfield.

The principal seam is the Top Hard, which is the equivalent of the famous Barnsley Bed in Yorkshire and is about six feet thick. It is a composite seam yielding both steam and domestic coal.

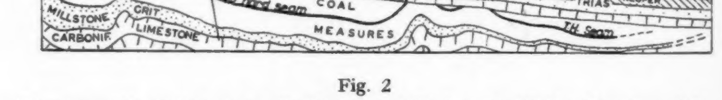

Fig. 2

Diagrammatic section across the Notts. and Derbys. Coalfield. Based on data in "The Concealed Coalfield of Yorkshire and Nottinghamshire", H.M.S.O. 1951

(1) It should be noted however that, but for a stoppage caused by a strike in one district, production in Yorkshire would have slightly exceeded that in the East Midlands.

High Productivity

Coal mining in the East Midlands is characterised by its high productivity, i.e. a high rate of output of good quality coal at relatively low cost ; it is this condition which gives the region its special significance in the national picture. Four factors combine to promote this exceptional productivity :—

(1) The highly favourable geological conditions.

(2) The relatively high proportion of well-equipped mines, largely irrespective of age.

(3) The relatively high degree of mechanisation, making for a high output per man employed.

(4) The absence of labour troubles, resulting from a tradition of good relations between employers and employees established long before nationalisation.

Compared with other British coalfields, as the following table shows, the importance of the East Midlands is seen firstly in terms of total output and secondly in the output per man shift, the latter figure being higher than that for any other field and 50% higher than the average for the country.

COAL OUTPUT, 1955*

	(i) Regional Production (Millions Tons)	(ii) Output per Man Shift (All Workers) (Tons)	
Scotland	22·04	1·04	
Northern (N. and C.)	13·48	1·19	
Durham	25·58	1·01	
N.W. (Lancs. and N. Wales)	15·63	1·10	
N.E. (Yorks.)	43·90	1·34	
E. Midlands	46·06	1·83	(cf. National Average 1·23)
W. Midlands	17·74	1·30	
S.W. (S. Wales, etc.)	24·23	0·93	
S.E. (Kent)	1·53	0·97	
Total (mined)	210·19		
Opencast	11·37		
Total	221·56		

* Figures from N.C.B. Report and Accounts for 1955, Vols. I and II.

The output per employee is even more emphasised if reference is made to the output per man shift for coal-face workers only (see Figure 3). In other words the large production in the East Midlands is achieved by a relatively small labour force. Broadly speaking the East Midlands provide over one-fifth of Britain's coal with only one-seventh of her miners.

Viewed from the standpoint of production costs, the East Midlands has long ranked as an economical area. The following table showing production costs per ton for the different coalfields in 1938 and 1954 respectively shows that both before the war and at present the lowest cost areas were those of the East Midlands, namely Notts., Derbys., South Derbys., and Leicestershire.

COAL

Average Production Cost per Ton(1)

1938	s.	d.	1954	s.	d.
Leicestershire	13	8	Leicestershire	40	7
Notts.	14	1	S. Derbys.	40	11
S. Derbys.	14	8	Notts.	48	3
N. Derbys.	14	8	N. Derbys.	50	6
Northumberland	14	10	Yorks.	56	4
Scotland	15	2	Warwicks	57	2
Durham	15	5	N. Staffs.	59	8
Yorks	15	6	**National Average**	**61**	**11**
S. Staffs.	15	8	Northumberland	64	2
National Average	**16**	**0**	Scotland	69	0
Warwicks.	16	2	S. Staffs.	70	0
N. Staffs.	16	7	Durham	70	7
S. Wales	18	3	S. Lancs.	70	8
Kent	18	9	Kent	75	8
S. Lancs.	18	10	S. Wales	76	6
Cumberland	20	3	Cumberland	86	7

It is interesting to note too, that while Yorkshire and some of the other Midland fields come next in order of cost per ton, the great fields of the past such as South Wales, Northumberland and Durham now rank among the most expensive producers(2). It must be made clear however that although production costs in the East Midlands are low, the area is located inland and distribution costs are high since much of the coal is sent by railway over considerable distances, especially to London and the south.

The Most Profitable Coalfield

Low production costs in the East Midlands have a close bearing upon another distinguishing feature of the region, i.e., the fact that it is the most profitable of all the N.C.B. Divisions. With many coalfields showing a loss per saleable ton, the overall profit in 1955 was 9d. per ton while for the East Midlands it was 7s. 5d. per ton. The corresponding figures for 1954 were 1s. 7d. and 6s. 11d. Under nationalisation the East Midlands therefore does much to keep the less fortunate fields in operation.

Profits however are not uniform throughout the mining districts and reference to the constituent Areas within the East Midlands Division from this standpoint, reveals significant differences. Areas 1 (Chesterfield), 4 (Alfreton), and 5 (Ilkeston) contain rather old, small and medium sized and not very deep collieries situated chiefly on the exposed field (see Figure 4). Area 3 (Edwinstowe) embraces a number of large modern deep collieries on the concealed field, nearly all of them raising three-quarters of a million to over one million tons annually. Area 6 (Nottingham) is somewhat similar to Area 3 save that some of the mines are older. Yet it does include the newest of all the collieries, that of Calverton completed in 1952.

The map showing profit per saleable ton by Areas for the year 1955 (Fig. 5) shows that those containing the most modern collieries, e.g. Area 3, are not necessarily the most profitable. It is true however that many of the older mines, as in Areas 1 and 5, are among the least profitable. Actually the highest profit is made in Area 4 which consists

(1) From the *Colliery Yearbook*, 1956, p. 517.
(2) From the *N.C.B. Report and Accounts for* 1955, Vol. II, pp. 30-31.

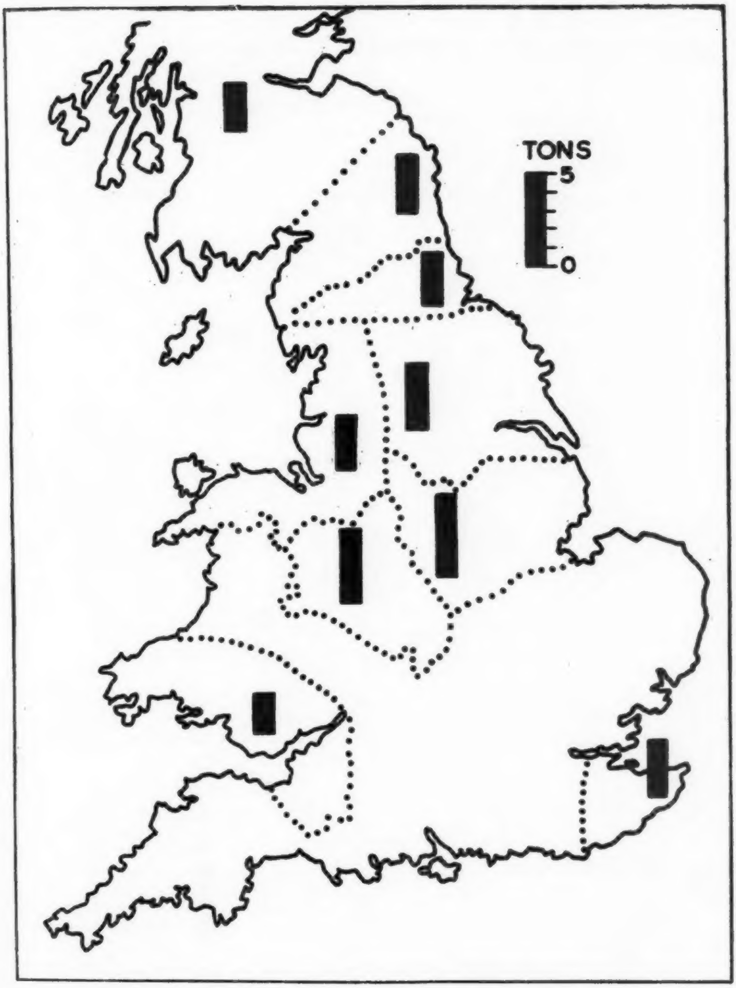

Fig. 3 Divisional output per manshift at the coal-face

of mainly small and medium-sized units usually of considerable age. This is largely accounted for by recent mechanisation permitting the extraction of thinner seams which have been left unworked in earlier years. Clearly, variations in Area profitability raise many questions but the important point is that in every Area the profit per ton is substantially greater than that for the country as a whole (1). Such then are the leading features of coal production in the East Midlands and some of the reasons which account for its prominence in the British coal industry today.

(1) An important contribution to the study of profitability, dealing with the numerous factors involved, is the following: F. S. Atkinson and P. A. Walker, "Coal-Mine Profitablility", *Iron and Coal Trades Review*, clxxiii, July 13th, 1956.

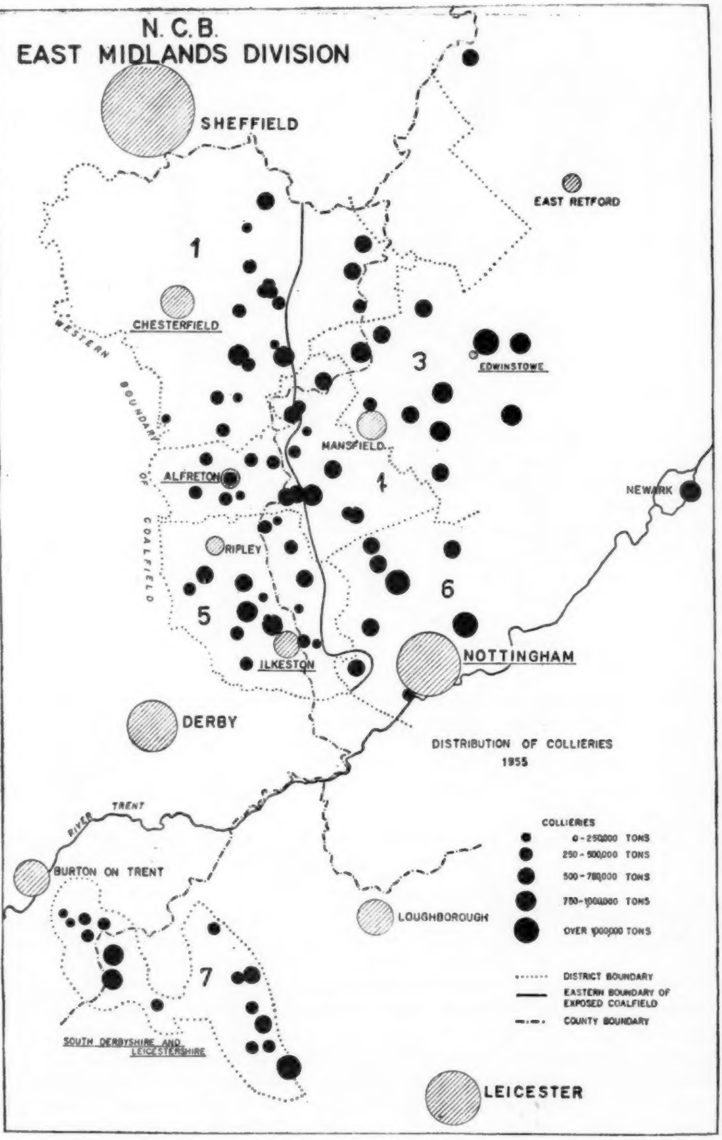

Fig. 4

Area Boards and size of collieries in the East Midlands Division. (Based on information supplied by the Deputy Chairman, East Midlands Division, N.C.B.) Area No. 2 no longer exists separately

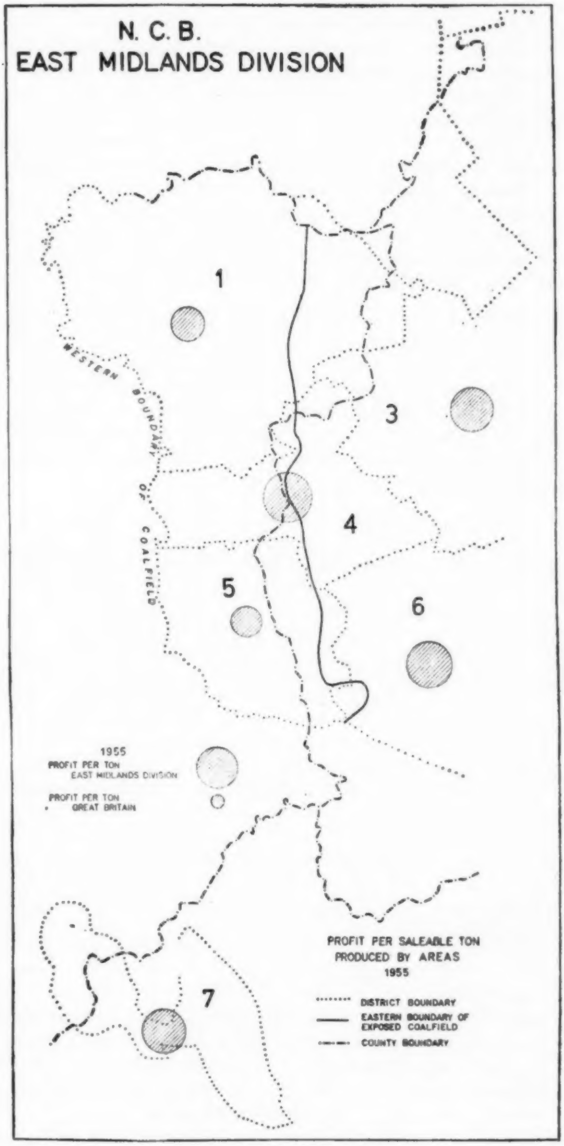

Fig. 5

Profit per saleable ton by Areas, 1955

Present Day Trends

What is the precise rôle of the East Midlands towards solving the current problem of adequate fuel and power production ? Traditionally as an inland producer, the output has been directed predominantly to the home market, domestic coal going to the London area and much of the south of England and, of course, over the East Midlands itself, steam coal providing the basis for industrialisation on the coalfield and in many surrounding centres. How far is this broad pattern of disposal undergoing change ? Although never significant as an exporting field, small shipments from the East Midlands to Scandinavian countries have long been made through the ports of Immingham and Goole. In the past few years however some 4-5 million tons have been exported annually, chiefly to Denmark and to Eire, the East Midlands now being the largest supplier of domestic coal to the latter country.

More attention is now being devoted to coke production. Whilst the output of metallurgical coke is almost negligible, there is a rise in demand for it in domestic and industrial markets. To help meet this demand, a large coking-plant has been erected near Chesterfield to treat coal from a group of collieries in the district(1). Similarly, greater attention is now being given to gas production and to the preparation of special fuels, notably smokeless fuels, in view of the general acceptance of the clean air policy.

Most spectacular of all is the part now being played by the East Midlands in the expansion of electricity generation. By contributing an increasing proportion of the total output to electricity production each year, the East Midlands now leads the country in this respect. In 1955 some 12 million tons, i.e. over 25% of the total output, were delivered to generating stations, providing about 28% of the national tonnage used for this purpose. It is anticipated that by 1960 the proportion of the East Midland output delivered to generating stations will rise to about 37%(2).

The post-war programme of building new power stations has also relied heavily upon the East Midlands for the location of the stations. On the whole wherever possible such stations are sited with reference to coal resources and supplies of cooling water. Thus sites along the banks of the Trent have been chosen for a chain of large generating stations, using water from the river and situated within a short rail haul of East Midlands coal. With several of these stations already in operation this chain will in the next decade or so constitute an axis of power production unequalled in Britain(3).

Future prospects

The rising importance of the East Midlands to the British coal industry in providing an increasing share of the home requirements is shown not only by the continual expansion in output, which amounts to 40% since nationalisation in 1946, but by the large capital expenditure,

(1) See "The New 'Avenue' Coke-Oven Plant at Wingerworth", *The East Midland Geographer*, No. 5, June 1956, pp. 37-38.

(2) Based on J. W. Peattie, in discussion on "275 kV developments on the British Grid System", *Proc. Inst. Elect. Engineers* (99) 1952, Part 2, p. 601.

(3) E. M. Rawstron, "Changes in the Geography of Electricity Production in Great Britain", *Geography*, Vol. XL, April 1955.

actual and projected, which is to ensure even further expansion. This expenditure provides for several new collieries, for the reorganisation of many existing ones and for new coal-treatment units. Besides the main field, similar developments are projected for the South Derbys. and Leicestershire area, where workable reserves also occur. Figures recently published by the N.C.B. show that the East Midlands is among the three Divisions to receive the greatest allocation of capital by 1965. These are the North Eastern Division (£194 millions), the East Midlands (£191 millions) and Scotland, largely the eastern fields (£185 millions)(1). Moreover, figures showing a comparison of the actual output for 1955 with the estimated output for 1960 and 1965 resulting from such expenditure, indicate that the East Midlands will remain the country's leading coal producer and will by then have drawn still further ahead of its neighbour, the North Eastern Division.(2) Looking further into the future and assuming an increasing contribution from atomic power, the East Midlands according to present N.C.B. policy will continue to contribute for a long time to come the largest share of any region to the country's fuel and power requirements.

(*The author gratefully acknowledges the help given by Mr. W. L. Miron, O.B.E., T.D., Deputy Chairman, East Midlands Division, National Coal Board, in the preparation of this paper.*)

NOTTINGHAM : ITS URBAN PATTERN

D. C. Large

Nottingham, a city of over 300,000 inhabitants, shows clear evidence of its historic settlement forms. Street patterns of the Anglo-Saxon and Norman periods are preserved almost intact and it is possible to recognise the effects of restraint upon building due to the jealous preservation of the burgesses' common lands adjacent to the medieval town. This restriction which lasted well into the nineteenth century provides a very exceptional if not unique feature in Nottingham's urban development.

The Early Town

The physical setting of the city including details of the original siting has been described elsewhere(3) and it is sufficient here to refer to the southern edge of the Bunter Sandstone outcrop which afforded a dry and naturally defensible position overlooking the Trent floodplain. The two sandstone hills separated by a shallow depression opening southwards towards the Trent became the area of the medieval town. The Anglo-Saxon *burh* was generally a defended dwelling place, the term being extended to mean a larger fortified area and later on a walled

(1) *Investing in Coal*, National Coal Board, 1956, p. 16.

(2) Ibid. p. 14.

(3) K. C. Edwards, "Nottingham and its region" in *A Scientific Survey of Nottingham and District*, British Association for the Advancement of Science, 1937, pp. 25-38.

K. C. Edwards, "Nottingham", *Geography*, Vol. XX, June 1935.

K. C. Edwards, "Some Location Factors in the Development of Nottingham", *The East Midland Geographer*, No. 5, June 1956.

town[1]. In the case of Nottingham an Anglian settlement of this nature was already established in the ninth century on the eastern hill, with earthworks protecting the site except where the sharply falling ground gave a natural defence. The *burh*, with an area of about 39 acres, served as a fortified administrative centre, first under the Anglo-Saxons and afterwards under the Danes who captured it and made it one of the Five Boroughs.

At the time of the Norman Conquest Nottingham became a military base. Between 1068 and 1120 a castle was erected on the western hill providing a garrison centre of considerable size, around which a second township developed[2]. The latter was predominantly military in character and at first almost entirely Norman-French, in contrast to the wholly civil township of the English hardly more than a quarter of a mile to the east. Earthworks and eventually walls were raised eastwards of the castle, both north and south, to protect the lower area lying between the two centres. Henceforward Nottingham grew in importance. Previously it had little commercial significance beyond being a focus for the loosely organised tribal communities in the neighbourhood, although the pre-Conquest *burh* had its own market-place located at what is still called Weekday Cross. Gradually, as the two boroughs grew together in peaceful co-existence, the lower ground between them, a natural meeting point, became used as a large market centre in which important fairs were held. In fact it became the largest market-place in the country.

Growth without Expansion

Despite the establishment of many crafts and trades and a corresponding growth in commerce, the area occupied by the medieval town did not expand. Though the cartographic record only dates from 1610, archaeological evidence makes it clear that little change in the limits of the town had occurred over the preceding centuries. As far as the boundaries and the basic lay-out are concerned therefore, Speede's map presents a picture of medieval Nottingham. Reference to Figure 1 shows the survival to 1610 of the relatively open pattern of streets within the Anglian *burh*, not haphazard but nicely adjusted to the local relief; it also shows that within the Norman borough the castle became the focus of streets radiating north-eastwards and eastwards, making connection with the old *burh* on either side of the great market place and to the south of it. On the north side of the town, along the line of the present Parliament Street, a road followed the course of the town wall. Speede's map itself, by its reference to streets, churches and other individual items, indicates the functional contrasts between the two boroughs. Thus the concentration in the old *burh* of ancient crafts and trades is shown by such street names as Bridlesmith Gate, Fletcher Gate, Barker Gate, Bellar Gate, while in the Norman area Castle Lane, Whitefriars Lane and Blackfriars relate to the garrison and the monastic institutions. Another fact made obvious by this map is that Nottingham in Speede's day was by no means fully built-up for there were still large gardens, orchards and even fields between some of the streets. The town could still support a larger population within its existing confines.

(1) C. Stephenson, *Borough and Town, a Study of Urban Origins in England*, Cambridge, Mass., 1933.

(2) E. Green, "Nottingham Castle", *Arch Journ.*, Vol. VIII, Dec. 1901, pp. 365-397.

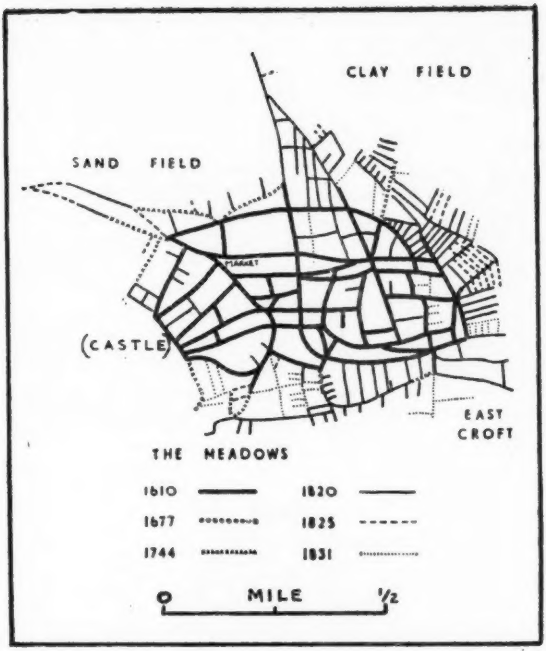

Fig. 1

Stages in the growth of the street plan of Nottingham from 1610 to 1831

Subsequent maps of Nottingham, covering a period of more than two centuries, including those of Thoroton (1677), Badder and Peat (1744), Wild and Smith (1820) and Staveley and Wood (1831) show that despite a large increase in population surprisingly little expansion in the area of the town took place(1). In 1610 the population was about 3,500 ; by 1740 it was 9,890 ; by 1779 it was 17,711 ; in 1801 it was 40,415 and in 1831, 50,680. Yet until 1800 the only extensions to the town consisted of a limited advance to the south as far as the Leen (a small tributary of the Trent) and the beginnings of development outside the old western gateway at Chapel Bar. Even by 1831 as shown on Staveley and Wood's map the position had not greatly changed (see Figure 2). Some expansion eastward from the old *burh* had occurred ; ribbon growth had taken place to the north and west along the Mansfield and Derby Roads respectively but to the south there was still no development across the Leen. Thus in 1831 Nottingham was an acutely overcrowded town accommodating a population of over 50,000 in the same area which, more than two hundred years previously, had sheltered fewer than 4,000 inhabitants.

Few towns at this time could have been more congested. To provide for its people many narrow streets and alleys lined with mean houses were made between existing thoroughfares ; interior spaces were filled with buildings and rows of dwellings were erected wherever room

(1) Reproductions of these maps, with the exception of that of 1677, are to be found in J. D. Chambers, *Modern Nottingham in the Making*, Nottingham, 1945.

could be found. This phase of intensified growth within, unaccompanied by expansion outside, exercised a profound influence on the urban morphology, for without affecting the size and shape of the original elements, it substantially altered their texture.

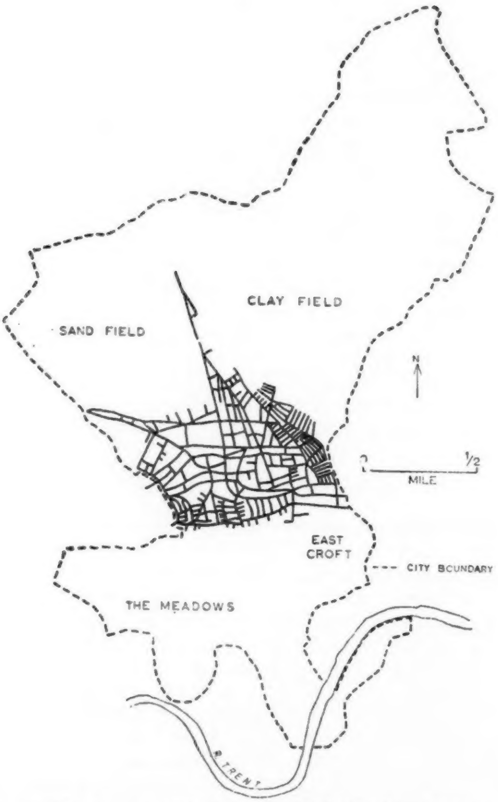

Fig. 2. Nottingham in 1831, the municipal boundary and open land

Paradoxically, in 1831 there were around the town, yet within the municipal boundary, no less than 1,442 acres of open land, used largely for grazing. These lands, consisting of the Clay Field, the Sand Field, the East Croft and the Meadows (Fig. 2), were open fields and commonable tracts which had never been enclosed. They were owned by the municipality or by individual burgesses and were subject to common rights for part of each year. Successful opposition to the remission of these rights was the real obstacle to the extension of the town. Resistance, often led by a small number of the burgesses, supported by owners of property in the town who feared the loss of their rents if expansion took place, lasted for a long time. Eventually pressure of public opinion aided by the extension of the franchise resulting from the Reform Act led to the passing of the Nottingham Enclosure Act of 1845. The town then literally broke its bounds(1).

(1) For a full treatment of this phase in the town's history, see J. D. Chambers, *op. cit.*

In the meantime significant developments in lace and hosiery making had made Nottingham prominent as an industrial centre. Though hosiery, like some branches of the lace trade, long remained a domestic industry, there was an ever-increasing demand for labour which added further impetus to the growth of population. Some of the neighbouring villages inevitably participated in this growth. Thus to the north of the town, houses and workshops, built soon after 1820 by working-men's co-operative societies at Carrington and Sherwood, continued the linear development along Mansfield Road which was such a conspicuous feature on mid-nineteenth century maps. The later annexation and integration of these and other places with the city were a logical outcome.

After the Act of 1845

Following the Act of 1845 the tide of new building spread rapidly over the newly enclosed areas, particularly to the north, north-west and north-east, while to the south streets were built beyond the Midland Counties Railway (opened in 1839) in the district known as the Meadows.

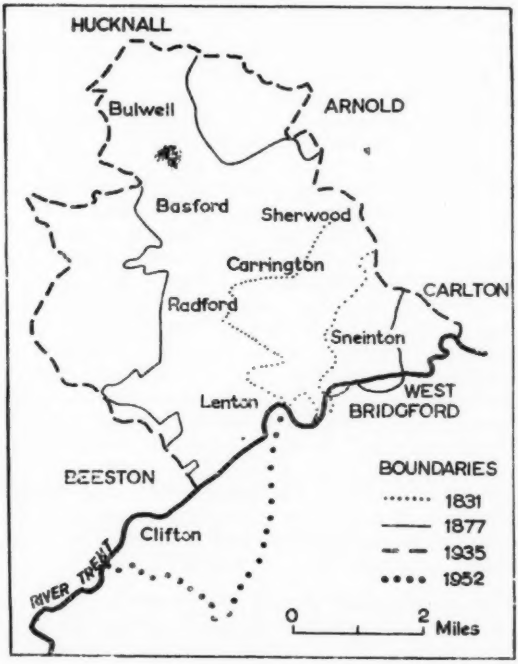

Fig. 3

The municipal boundaries 1831 to 1952. The small areas acquired by the city in 1877 south of the Trent passed to West Bridgford in 1952

With the boundary extension of 1877 several outlying centres were incorporated, providing nuclei around which the city rapidly expanded. Such were Lenton, Radford and Basford along the Leen valley to the west, Carrington and Sherwood to the north, as already mentioned, and

Sneinton to the east (see Figure 3). Most of this new phase of building was unplanned and gave rise to districts of indiscriminate housing, factories and commercial premises. Like other large industrial towns Nottingham experienced a Victorian sprawl. Some of these developments were naturally directed towards relieving the accumulated congestion of the pre-1845 era. The process of mitigating the intense overcrowding has however been slow and traces of the legacy of that period remain even today.

In other respects the municipal authority has been far-sighted in adopting measures for the improvement of the town. Thus following the Enclosure Act of 1845, some 130 acres were set aside for public parks and open spaces resulting in the Arboretum (public park and gardens), the Forest (park and recreation ground) and Queen's Walk, one of the earliest instances of amenity development in the country. Later on, in the 'eighties, an enlightened programme of road construction led to the building of Castle, Lenton, Radford and Gregory Boulevards which extend along the south, west and north margins of the town and which still provide a conspicuous feature of the urban plan. These thoroughfares, now largely superseded by an outer ring road form the "inner boulevards" and remain of great value for internal traffic.

Much of Nottingham's growth in the present century as far as residential areas are concerned, has been in the form of local authority financed housing estates following the Housing Subsidy Act of 1919. The Corporation has played an exceptionally large part in extending the housing of the city. Between 1919 and 1939, it built 17,095 houses compared with 9,011 built by private enterprise. Most of this development took place on the western and northern fringes, the numerous geometrical lay-outs forming a conspicuous feature of the modern city plan. After the second world war, a similar expansion took place, again chiefly to the west and north, the estates in some cases lying adjacent to the earlier ones. At this stage however the demand for housing and its related needs (schools, churches, shopping facilities, etc.) had become so great and the amount of available land within the municipal boundary so inadequate that the city was confronted with an acute problem. Boundary extension was virtually impossible on account of the encirclement by the contiguous urban districts of Hucknall, Arnold, Carlton, West Bridgford and Beeston. A solution was found by the acquisition of territory south of the Trent in 1950 for the promotion of yet another large estate at Clifton (see Figure 3). This project which is now being developed as a further planned community for an ultimate population of 25-30,000 thus provides an additional morphological unit. Its creation has also made imperative the building of another bridge over the Trent which is now in course of construction.

Industrial development during the present century has also been extensive and problems of location have continually arisen. Besides making use of relatively small interior sites, the chief areas available for expansion have been the Leen Valley and the Trent floodplain, both having adequate road and rail communications as well as flat ground.

Principal Morphological Units

From this general account of the development of the city, the broader morphological units may be adduced. Firstly, in and around the great market-place (known officially as the Old Market Square since the removal of the market to covered premises in 1928) is the leading retail

and commercial area which also includes many of the larger places of entertainment. Adjacent to this on the east, around St. Mary's Church on the site of the old *burh*, is a small area known as the Lace Market devoted to offices and warehouses of lace-manufacturing firms, though no longer exclusively so. To the west, around the site of the Castle, the focus of the Norman borough, commercial premises are interspersed with offices, residential streets and the hospital quarter.

Secondly, beyond the limits of the medieval town are the districts of mixed character (residential and industrial, with local concentrations of retail shops) which grew up following the letting down of the barriers to urban expansion in 1845. These extend fanwise between the main roads which radiate from the old town. Though varying in type according to income group, the residential parts of these districts are more or less solidly Victorian in character. One of these areas to the south of the old town forms the large block of artisan housing and factories in the Meadows which in places reaches to the Trent.

Thirdly, old centres formerly lying outside the town and now largely enveloped by the post-1845 extension, are still recognisable by a measure of local life focussed upon churches, shops and local social and recreational facilities. Such are Lenton, Radford, Basford and Bulwell along the Leen Valley, Sherwood to the north, the St. Ann's Well district to the north-east and Sneinton to the east. Fourthly, though belonging to different periods, the residential districts of The Park and Mapperley Park with their larger houses and often spacious gardens form two separate and distinctive units.

Fifthly, the inter-war housing estates which form a discontinuous zone to the west, north and east, supplemented by those built after the second war present a vast and largely homogeneous accretion to modern Nottingham. Though similar in origin and therefore falling into the same functional category, the development at Clifton may justify recognition as a separate unit in view of its independent location. Lastly, much of the Trent Valley within the city boundary like that of the Leen, is now occupied by industrial premises, railway yards and recreational facilities. In fact it is only here and along the tributary valley that Nottingham may be said to possess an industrial zone, so great is the sporadic occurrence of industry in all the older parts of the city.

SERVICE CENTRES IN NOTTINGHAM

A CONCEPT IN URBAN ANALYSIS

I. G. Weekley

During recent years a number of attempts have been made to define town status and to designate grades in an urban hierarchy. If it is thus possible to denote grades of service centre both within the country as a whole and in the rural area, so it should be possible—and equally valuable—to denote grades of service centre within the built-up area of each large city. This is especially true at the present time when the size of many cities reduces the possibility of a daily shopping visit to the centre, despite the increased efficiency of communications, so that the local "service centre" within the city has an important part to play in supplying at least the day to day needs of local inhabitants.

Modern town planning and policies of decentralisation have emphasised the need for local consciousness and independence within the city area, and have made clear the value of the "neighbourhood unit" as a concept in urban development. Each of these neighbourhood units in either a new town or a replanned city area must have a service centre adequate to supply all regular local needs for shopping, entertainment, financial facilities and community life. It is apparent that a comprehensive survey of the existing facilities and an analysis of the present service centres is an essential preliminary if the policy is to succeed and if local community character is to survive.

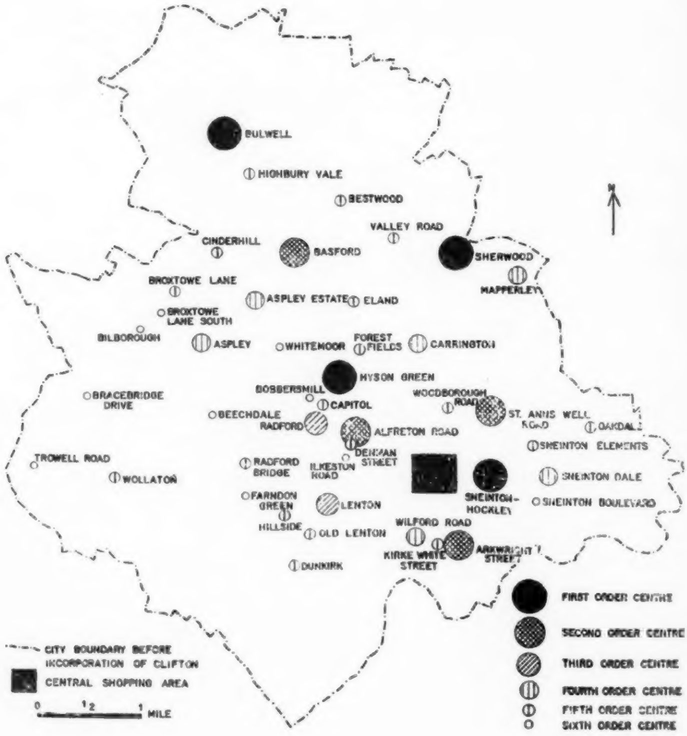

Fig. 1

Service centres in Nottingham

The standard methods of urban analysis are concerned chiefly with describing an ordered succession of belts outwards from the central business district. Attention is rarely devoted to the individual service centres within the built-up area of the city however obvious these may be in the field. It is in part to remedy this deficiency that the accompanying map (Figure 1) shows 43 service centres of various degrees of importance within the city of Nottingham. It is meant purely as a

preliminary survey and is based solely on field study—no statistical analysis of any sort having yet been attempted. The aim here is to denote service centres in the city which are readily distinguishable in the field, and which are capable of supplying certain categories of needs and services to a local population.

A service centre may be defined as a group of shops and other facilities separated from any similar group by an area of open space or of residential or industrial development in which such facilities are absent. In Nottingham there is little difficulty in distinguishing these centres except near the central shopping area. Here, such streets as Alfreton Road and Arkwright Street appear to have a distinct service hinterland and local consciousness but are clearly connected with the main central area by belts of lower shopping density, as at Canning Circus and Carrington Street respectively, though they possess no shops or facilities of more than local significance which would warrant their inclusion within the central shopping area.

A number of common criteria were analysed in order to describe a hierarchy of urban service centres and it was found that many of the criteria, such as schools and hospitals, used in defining simple town status were of little value in this instance. The final criteria selected were almost wholly retail and entertainment functions though in some cities local newspapers may be an additional guide to definition—Bulwell being however the sole example in Nottingham. The actual criteria used in evaluating six orders of centre in Nottingham are as follows :

First Order Centres :	3 banks. One or more Cinemas. A Woolworth's store. A Post Office. A Boot's chemists'.
Second Order Centres :	3 banks. One or more Cinemas A Post Office. A Chain grocery store.
Third Order Centres :	As above (Second Order) but with only 2 banks, including a Savings bank.
Fourth Order Centres :	As above (Second Order) with only 1 bank.
Fifth Order Centres :	A Post Office and a Chain grocery store. (In certain instances a bank or a cinema may replace one of these).
Sixth Order Centres :	A Post Office or a Chain grocery store.

It should be noted that each centre of whatever Order contains in addition to the facilities mentioned above a group of small shops supplying basic daily needs.

When the fieldwork was initially planned it was assumed that the lowest grade of service centre would contain a post office and a branch of one of the chain groceries (Co-operative, Marsdens, or Farrands in Nottingham). However certain exceptions were allowed, as for instance at Oakdale Road (near Sneinton Dale), where there was a chain grocery store and a cinema though no post office (only a shop selling stamps). Finally a microcentre (Sixth Order Centre) was also included as being of some significance in certain areas and being indicative of a service centre capable of supplying basic daily needs.

The difficulties underlying the selection of criteria for defining urban service centres are even greater than in the case of simple town status(1). The ordinary town has normally to cater for a complete cross-section of the population. On the other hand the urban service centre is often concerned with only one particular class, so that the criteria in one area may be substantially different from those in another and a common factor difficult to discern. For instance a service centre in a middle class residential district such as Mapperley needs, among other facilities, banks, good class hairdressers and bookshops. In contrast Cinderhill, a mining quarter, has few services, but the presence of a Working Men's Club, a Boys' Club, and a group of small stores indicates a definite degree of local consciousness. Undoubtedly with further research in other towns the relevant criteria would become more readily apparent.

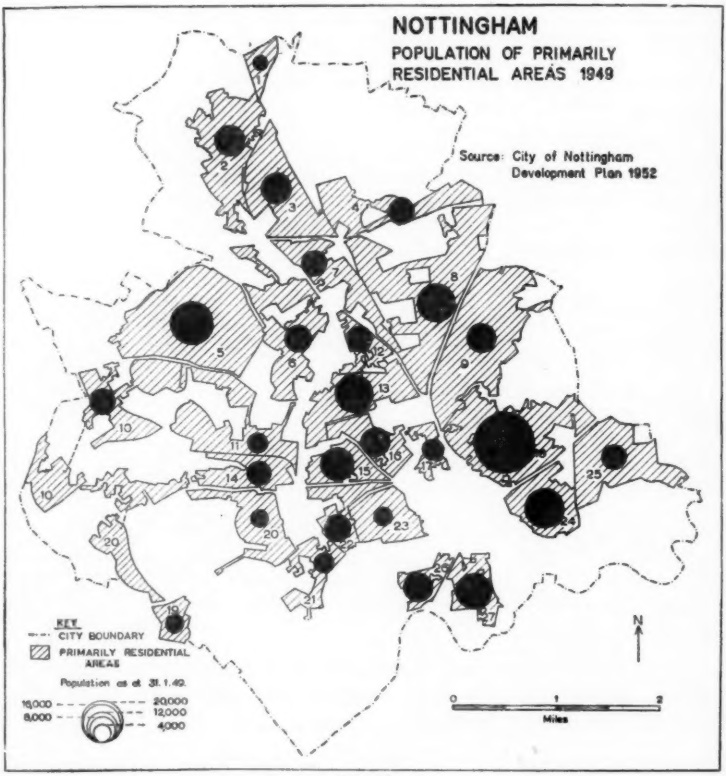

Fig. 2
The numbers on this map refer to the "primarily residential areas" as defined in the Development Plan

Figure 1 indicates that the main concentration of service centres is in a belt extending southeast-northwest from Arkwright Street to Bulwell. In this belt are six of the ten chief centres (Orders 1, 2 and 3). Of the others Lenton lies to the west, and Sneinton, St. Ann's Well Road

(1) *cf.* A. E. Smailes—"The Urban Hierarchy in England and Wales", *Geography*, Vol. 29, 1944, pp. 41-51.

and Sherwood to the east. Excluding Sneinton-Hockley which is less clearly defined[1], the three most important centres all lie in the northern and more densely peopled area of the city.

Once the service centres have been distinguished it becomes essential to examine their distribution in relation to other patterns. For example, comparison of Figure 2 with Figure 1 shows that there is some relationship with the broad population groupings within the city, but it seems that in certain areas the population may be relatively underserved. This appears to be the case in the newer residential areas to the west though planned expansion of shopping facilities there is being undertaken.

In these newer residential areas the service centres are recent and planned. Yet the genesis of all the service centres in the city represents a further feature of interest in the analysis, and three types of origin may tentatively be suggested.

(1) As a city spreads outwards its growth often overruns pre-existing smaller but distinct centres on its periphery. In the growth of Nottingham old village centres such as Radford and Basford were absorbed during the nineteenth century into the continuous built-up area. In the twentieth century the small town of Bulwell still further from the city centre similarly came within the city boundary. It is, however, no more within the built-up area now than are the urban districts of Arnold, Beeston and West Bridgford which adjoin the city. The site and to some extent the form of the service centres in these localities today were clearly determined by their existence prior to the city's outward spread. Their early start and the growth of the built-up area around them account largely for their subsequent expansion.

(2) Where no nucleus of retail and other service facilities existed previously local service centres developed in a more haphazard fashion. The most common result of this kind of unplanned origin is the occurrence at intervals along main radial roads of strings of shops with no true core. Often these lines of shops occur at major crossroads but in Nottingham at least they are most commonly restricted to the radial road, the intersecting road being almost entirely neglected. Examples of this type of origin in Nottingham are the centres at Sherwood, Wilford Road, and and Woodborough Road.

(3) Planned municipal housing estates of the twentieth century generally contain planned service centres often sited at the junction of the main feeder roads of the estates.

This brief discussion of the data shown on Figure 1 is but a preliminary survey of this aspect of urban geography. Clearly however the concept of the local service centre is of value not only in

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(1) Sneinton-Hockley is possibly a part of the Central Shopping Area, though it has a definite local consciousness of its own and is separated from the Centre by a belt of lower shopping density on Carlton Street. Mansfield Road which is similarly difficult to classify in an initial statement has no real consciousness and is fully connected with Parliament Street by services of more than local significance (e.g. Mechanics and Continental Cinemas), so that it is included in the Central Shopping Area.

urban geography but also in town planning. But much more detailed research is needed before the concept can become a generally accepted item in the geographical analysis of urban areas. Perhaps the most promising line for further research would be to attempt the delimitation of the areas served by the centres for various categories of needs. From this could be gained not only a more accurate measure of the adequacy of facilities in relation to the needs of the population dependent upon them but also an advance in the study of urban regions.

EAST MIDLAND RECORD

Atomic Power and The East Midlands

Articles in previous issues of *The East Midland Geographer* have emphasised the importance of the East Midland region in power production both as the source of the cheapest coal(1) mined in Britain today and as the optimum location for electricity generation(2). Expansion of both industries, electricity even more than coal production, is going ahead rapidly in the region. It is of interest now, with the recent opening of the first atomic power station to yield current in worthwhile quantities to the public supply system, to examine the likely effects of the advent of atomic power on the relative importance in Britain of the East Midlands in power production.

So far as coal is concerned little change is likely for very many years. If, as is hoped, standards of living are to be greatly increased during the next twenty-five years, all the coal and atomic power that can be economically produced will be needed and probably double our present oil imports. Thus with a few localities excepted expansion of coal production in the country as a whole is assured for the next twenty-five years and probably for an even longer period. In the very long run of, say, from fifty to a hundred years hence, as atomic power becomes cheaper through technical improvement and as coal becomes more costly to mine through the exhaustion of the cheaply won deposits, coal production may decline considerably. But since most probably the East Midlands will remain the cheapest coal producing area in the country the region is likely to sustain a high output for a longer period than most other coal mining areas in Britain. If the technical changes forecast for the gas industry in the next few years take place then the prospects for the East Midlands with its output largely consisting of non-caking coal are further enhanced.(3)

No change in the relative importance in Britain of the coalfields of the East Midlands, other than their relatively greater expansion as already planned before the advent of atomic power, is therefore likely in the immediate future or for the next twenty-five years. Beyond that period the East Midlands region is likely to expand or at least to maintain its output for far longer than other areas. In short the increasing use of atomic power should emphasise still further the position of the East Midlands in the geography of coal production in Britain.

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(1) E. M. Rawstron, "Three Maps on Coal Production", *The East Midland Geographer*, No. 1, June 1954, pp. 20-23.

(2) E. M. Rawstron, "Power Production and the River Trent", *The East Midland Geographer*, No. 2, December 1954, pp. 23-30.

(3) F. J. Dent, "Town Gas Production by Gasification Processes", *Advancement of Science*, Vol. 9, No. 44, March 1955, pp. 450-454.

As regards electric power production in the East Midlands a similar argument should hold but with a shorter time scale. Atomic power is at present more costly than electricity made from either coal or oil. Within ten years, more or less, atomic power may be the cheapest source of power for electricity generation in localities distant from the cheap coal producing areas. It will therefore replace first what would have been coal-fired or more probably oil-fired stations on the south-eastern, southern and south-western coasts of England. The first two atomic stations, near Bradwell on the Essex coast and near Berkeley on the Severn estuary are cases in point. The third, on the Ayrshire coast, is less readily justifiable but it is preferable to oil or coal in that locality given that coal supplies in Ayrshire are likely soon to be inadequate for local demands. There would seem, however, to be an element of Scottish national prestige involved in the choice rather than economic necessity.

As the cost of atomic power falls further relative to that of coal the next stage will be reached when stations will probably be established on the coast nearer the major industrial areas of South Wales, the North-East Coast and especially Lancashire. The last named should be one of the earlier candidates for locally produced atomic power but all three areas are eligible at this stage because they all produce high cost coal and have no or very little possibility of expanding their output economically. In short, estuarine and coastal sites, first in southern England and later near the major coastal and near-coastal markets elsewhere in the country, are likely to be chosen for atomic stations in the not too distant future. The coastal or estuarine site is important on account of the very great demands for cooling water at the atomic station which are at present considerably in excess of those for coal fired stations. Interior sites on major rivers but using cooling towers in addition will probably be required in the rather more distant future. The Rivers Severn and Thames especially may become important in this respect : but it is conceivable that the gas-turbine used to supply peak-load demands to interior concentrations of population may be relatively more important than atomic power in inland areas (e.g. the West Midlands), at least for a transitional period. Indeed in the country as a whole the gas-turbine may become important in providing flexibility of supply in conjunction with the less flexible atomic base-load and intermediate load stations.

It will be some time, however, before atomic power becomes cheaper than electricity produced from cheap coal in the East Midlands : and as the foregoing discussion implies the coal-fired stations on the Trent are likely to be the last major group to be closed down and replaced either *in situ* or elsewhere by atomic plants or gas-turbines. It is therefore reasonably safe to predict that for a long time in coal and for a somewhat shorter period in electricity the East Midland region is likely to remain one of the country's most important sources of power. Certainly it should be virtually the last area to change to the new methods of power production because its costs in coal and electricity production are comparatively so much lower than in most of the rest of Britain.—E.M.R.

A Village Survey

An outline study of the village and parish of Little Eaton near Derby, recently published, represents the results of observation and enquiry undertaken by members of the local W.E.A. class in Geography under the guidance of their tutor, Mr. W. O. Butler. The booklet, which

is illustrated by sketch-maps and photographs, deals briefly with various aspects of the parish, physical and cultural, using historical data both to explain and to show the significance of many of its present features. As a result, many points of interest emerge. The chief value of such a study, apart from those who know the locality, is of course to those who participate in it. Unlike many surveys of this kind which are begun with enthusiasm but never completed, the group at Little Eaton has set an example in preseverance and enterprise which others should be encouraged to follow.

Population Changes in Kesteven

In a recently published booklet (County of Lincoln, Parts of Kesteven : A Supplement to the County Survey of 1950—The Population of the County 1901-1951, by K. R. Fennell, 1955), a useful explanatory study of population changes has been made. Tables and diagrams dealing with natural change, migration, age and sex structure are informatively dealt with, attention being drawn to the various factors affecting changes in distribution, notably the effect on the census figures of the location in Kesteven of numerous military and defence establishments. Isopleth maps showing different aspects of population change form the basis for discussion of the variations in distribution over the period covered. The isopleths delimit areas of change "based on the known location of habitations". Since it is assumed that increases are likely to have taken place in the locality of the settlement nucleus, while decreases are likely to have affected the whole of a particular parish, the general tendency has been for the areas of increase to be more tightly drawn than the areas of decline. In his analysis the author interprets the facts both in the light of local conditions and in terms of factors operating outside the county. Thus the overall increase between 1931 and 1951 at a rate (18·7%) almost double the national figure (9·5%) is attributed mainly to two causes (i) the accelerated overspill from the city of Lincoln and (ii) the extension in both size and number of military establishments, mostly aerodromes having considerable civilian as well as service personnel. Of the four urban centres in the county, Sleaford, Bourne, and Stamford have grown but slowly, while the more substantial growth at Grantham dates chiefly from the second war which brought an expansion of the town's engineering industries. In the rural areas agriculture gives support to a diminishing proportion of the population even in this traditionally farming county and in this respect the smaller villages have suffered more than the larger ones. It is in the latter, largely because they are generally more fully serviced, that housing authorities have erected almost all the new dwellings.—D.R.M.

Refresher Course for Grammar School Teachers

A one-day refresher course for specialist teachers in grammar schools, arranged by the University of Nottingham Institute of Education and the Department of Geography, was held on Saturday, November 3rd. This was attended by some sixty teachers from all parts of the East Midlands and from other places ranging from Sheffield to Coventry. Professor K. C. Edwards opened a discussion on the question, "Should we all mean the same thing by Geography ?" Mr. F. A. Barnes gave a talk on "Lines of development in Physical Geography" and Mr. J. P. Cole spoke on "Teaching the Geography of the U.S.S.R.". Each contribution was followed by useful discussion.

International Geographic Congress, Rio de Janeiro

The Eighteenth International Geographical Congress was held in Rio de Janeiro in August of this year and was attended by delegates from 44 different countries. It was the first time the Congress had been held in Latin America and the first time in the southern hemisphere. Great Britain was represented by a delegation of nearly twenty members headed by Professor J. A. Steers, as well as by Professor L. Dudley Stamp who, as President of the International Geographical Union, presided over the Congress as a whole. Professor K. C. Edwards as a member of the delegation contributed a paper on "The Significance of East Midlands Coal Production in relation to Britain's Fuel and Power Problem", a version of which appears in this issue. It is gratifying to record that *The East Midland Geographer* was included in an exhibition of geographical books and periodicals arranged by the organisers of the Congress.—K.C.E.

OBITUARY

Professor C. G. Beasley

We regret to record the death, on August 8th 1956 in Barbados, of Professor C. G. Beasley, C.M.G., M.A., at one time lecturer in Geography at Nottingham.

Cyril George Beasley, a Londoner by birth, was educated at Kilburn Grammar School and University College, London, where he graduated in 1921, being one of the first students under Professor L. W. Lyde to read for the newly introduced B.A. Honours degree in Geography. He became lecturer in Geography in the University College of Nottingham in 1922 and in 1931 was appointed to the Chair of Geography and Geology in the University of Rangoon. During the Japanese occupation (1942-45) Professor Beasley served with the government of Burma in Simla and in 1946 was appointed Economic Adviser to the Development and Welfare Organisation of the British West Indies, a post which he found as strenuous as it was rewarding to his energies and capacity for public service.

At Nottingham, with Professor H. H. Swinnerton he organised the first full degree courses in Geography (for external degrees of the University of London), devoting himself to the field of Human Geography and to Economic Geography in particular, as well as to regional work. Professor Beasley will be remembered by many students of the former University College for his stimulating lectures which combined eloquence and ease of manner with a prodigious memory. The publication of his pamphlet on *Local Geography* (T. Murby, London, 1924) came usefully at a time when field studies were barely recognised as an essential part of a geographer's training. Beasley's continual interest in numerous undergraduate activities into which, as with everything else, he threw himself with unwavering zest, won for him the esteem of all. His personal charm as well as his wit and sagacity made him an exceptionally congenial colleague. As one of the founders of the Geography Department in this University he made a permanent contribution and among the manifold benefits derived from his tutorship through several generations of students, not the least enduring was the intimate contact with his own cultured and liberal mind.—K.C.E.

HIGHER DEGREE THESES AND FIRST DEGREE DISSERTATIONS

Prepared in the Department of Geography

In the University, Geography may be read as a subject in the Faculty of Arts, under the Board of Studies in Law and Social Science (Faculty of Arts) and in the Faculty of Pure Science. Since the award of the Charter to the University in 1948 all students taking an Honours degree in Geography have been required to submit a dissertation as part of their final examination. Only those dissertations and higher degree theses relating to East Midland subjects are listed below. *Bona fide* students or research workers may be permitted to consult them on application to the Department.

1956

M.Sc.

The North East Coast of Lincolnshire. A Study in Coastal Evolution. D. N. Robinson.

M.A.

The Geography of Industry in Country Towns—the Counties of Lincoln, Northampton and Rutland. I. G. Weekley.

DISSERTATIONS

The settlement pattern and population trends of the central Lincolnshire Wolds. D. Butts.

A comparative study of the industries of Peterborough and Grantham. A. L. Semper.

Some aspects of economy, settlement and population changes in the Isle of Axholme. L. Vause.

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